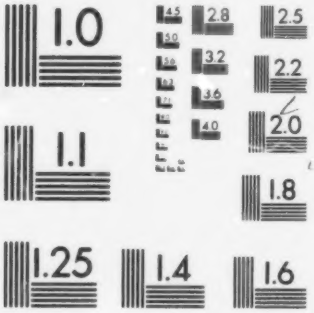
MS109

Micromedia Limited

The contents of this microfiche are copyright by the publisher of the original document. Please contact the original publisher for guidance in copyright matters.

96
0
mm
10
20
30
40
50
60
70
80
90
100


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

This statement was filmed with this document. If the pages of the document are less clear than this statement it is due to the poor photographic quality of the document.

NATIONAL MICROGRAPHICS ASSOCIATION

24x

Cette publication peut aussi être obtenue
en français sous le titre:
Le Canada et la science polaire

This report may be cited as:
Canada and Polar Science

Copies available from:
Circumpolar and Scientific
Affairs Directorate,
Department of Indian Affairs
and Northern Development,
Ottawa K1A 0H4
ISBN 0-662-15414-2

March 10, 1987

The Honourable Bill McKnight
Minister of Indian and Northern Affairs
House of Commons
Centre Block
Ottawa, Ontario
K1A 0A7

Dear Mr. McKnight :

We are pleased to present herewith our report on the feasibility and advisability of establishing a national polar institute in Canada. This report presents the results of a study requested of us by your predecessor, the Hon. David Crombie, in September, 1985.

Mr. Crombie asked us to advise him whether a new national polar institute was needed in Canada. Encouraged by him to address the question in the context of a general assessment of the state of polar research in this country, we traced the history of polar research, studied current problems and assessed future needs in light of the evolution of northern Canada and the rapidly changing nature of polar and global science. We canvassed a broad range of opinion within the Canadian polar research community, and among government officials, northerners, industry and private groups with northern expertise and interests. A large number of individuals and institutions responded with thoughtful submissions, proving to us that there is widespread interest in this subject and a general feeling that all is not right with the state of polar research in Canada.

Polar research in Canada is diffuse and decentralised compared to the situation in most other countries. It is undertaken by a large number of very different organisations who are sponsored by a range of interests for a variety of purposes. A polar research community as geographically dispersed and institutionally varied as Canada's requires a coordinated system of institutional support to give it cohesion and focus, to provide it with access to the information it needs and to enable it to work closely with the governments and the public it serves. Canada used to have a more coherent and coordinated system than it does now, but it has been allowed to deteriorate. As a consequence, the Canadian polar research community is not well-positioned to respond to changing national objectives in the polar regions and to the growing sophistication of international polar and global science.

The current public concern about Canadian sovereignty in the Arctic led us to pay particular attention to international developments in the polar regions. We found that other circumpolar nations and some influential non-Arctic countries are increasing their commitments to polar research substantially, and they are organizing their respective polar research communities to work more closely with national decision-makers and to take advantage of developments in world science. Canada must respond if our self-assertion as an Arctic nation is not to be compromised and our influence in the world of international polar affairs is not to wane.

We found much discontent among northern Canadians about polar research and an isolation of most of the Canadian polar research community from the dynamics of northern society. You are aware, of course, of the rapid political, economic and social changes in northern Canada and will appreciate the importance of bringing Canadian polar expertise to bear on some very complex and intractable problems. Local and regional priorities must be given due importance in determining Canada's needs in the field of polar research.

These are some of several problems affecting Canadian polar research, and their varied natures serve to illustrate the scope of the challenges facing Canada. We do not see solutions for problems as different as these emanating from any one institution. We do not recommend the establishment of a new national polar institute, but we are recommending a number of modest but significant steps to give the Canadian polar research community the support it needs to contribute to the attainment of national objectives in the polar regions. We believe these steps will improve Canadian scientific knowledge and polar technologies, enable Canada to maintain an effective position in international polar affairs, and increase the involvement of northern Canadians in Canadian and international polar research.

We hope that you find our report of interest and that, together with your distinguished colleagues, you will consider our recommendations. In accordance with the original request made of us, we have prepared our report in anticipation of its being made available to the general public, As we know that many, especially those who provided submissions to us, are eager to know the results of our work, we request your permission to make this report public as soon as it may be arranged conveniently.

Yours truly,

W.P. Adams

M.R. Gordon

P.F. Burnet

E. F. Roots

E.F. Roots

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY iv

1. INTRODUCTION 1

2. THE WORKING GROUP AND ITS ACTIVITIES 3

- 2.1 Origin and First Steps 3
- 2.2 Premises 6
- 2.3 Information and Opinions 8

3. THE PRESENT SITUATION 10

- 3.1 An Overview of the Present Organization of Northern Research in Canada 10
  - 3.1.1 Government activities 10
  - 3.1.2 Non-government activities 13
- 3.2 Canada and Polar Science 14
  - 3.2.1 North polar regions 15
  - 3.2.2 South polar regions and bi-polar studies 16
- 3.3 A Time of Change 17
  - 3.3.1 Changes in the Canadian north 18
  - 3.3.2 Circumpolar, bi-polar and international developments 20
- 3.4 The Driving Forces 22
  - 3.4.1 The military and geopolitical importance of the polar regions 22
  - 3.4.2 Sovereignty 25
  - 3.4.3 The dwindling of economic prospects 26
  - 3.4.4 Demographic changes 30
  - 3.4.5 Deterioration of habitats and general environmental quality 31
  - 3.4.6 Political evolution and devolution 33
  - 3.4.7 Influence of public interest groups 34

4. SOME MAJOR PROBLEMS - AND OPPORTUNITIES FOR ACTION 36

- 4.1 Public and Political Interest 36
- 4.2 The Perspectives of Northerners 40
- 4.3 The State of Northern Science 45

TABLE OF CONTENTS

Page

4.4 Problems in the Pursuit of Northern Science 50
4.4.1 Fragmentation and isolation 50
4.4.2 Identification of the northern dimension 54
4.4.3 Canada and international relations in the polar regions 60
4.4.4 A long-term commitment 63

5. TRENDS AND NEW DIRECTIONS IN POLAR SCIENCE 69

6. PREVIOUS REVIEWS AND RECOMMENDATIONS REGARDING NORTHERN AND POLAR SCIENCE 86

7. FINDINGS : NEEDS NOT SATISFIED BY THE PRESENT SITUATION ... 87

7.1 A Continuing Commitment to Northern Science 87

7.2 A Co-ordinated Information System for Polar Science and Technology 88

7.3 Science Relevant to the Needs of Northerners and the Involvement of Northerners in Polar Research 89

7.4 The Identification of Research Priorities and Areas of Scientific Weakness 89

7.5 A Canadian Focus for International Polar Research 90

7.6 A Focus for Public and Educational Interest in Northern and Polar Science 91

7.7 Attention to Scholarly Research on Polar Policy Issues 92

8. POSSIBLE OPTIONS AND SOME PROBABLE CONSEQUENCES 93

8.1 To Continue As At Present 93

8.2 A Co-ordinated Polar Science Programme Within the Federal Government 94

8.3 Increased Support of the Established Territorial and Non-Government Northern and Polar Institutes and Research Centres in Canada 95

8.4 Establish and Support a New Canadian Institute for Polar Research 97

TABLE OF CONTENTS

Page

8.5 Comments on Various Options 99

9. CONCLUSIONS - AND PREFERRED ACTIONS 101

9.1 A combination of Steps to be Taken 101

9.2 Features of the Proposed New Polar Research Bodies.... 103
- 9.2.1 Canadian Polar Research Commission 103
- 9.2.2 Canadian Polar Information System 107
- 9.2.3 Canadian "Polar House" 108

9.3 Financial Aspects 112

10. RECOMMENDATIONS 114

11. APPENDICES 117

EXECUTIVE SUMMARY

1. In September 1985, at the Arctic Policy Conference at McGill University, Montréal, the Minister of Indian Affairs and Northern Development invited the authors to consider and report to him on the advisability and feasibility of creating a National Polar Institute for Canada. In response we solicited opinions and suggestions from a wide range of interested persons, institutions and agencies in the private sector, in universities, and in the federal, provincial and territorial governments. We reviewed the history and development of polar sciences in Canada, and investigated the institutional structures and responsibilities for polar research in other countries.

2. There exists in Canada a large number of public and private institutions involved wholly or to some degree in the fields of northern science, northern research and the development of polar technologies. More than twenty federal departments and agencies, over thirty Canadian universities, numerous industrial organizations, several provincial and the territorial governments, as well as northern native development corporations and private organizations in both northern and southern Canada are engaged in some aspect of the development or application of knowledge pertaining to the Canadian North. One body, the Arctic Institute of North America was created by an Act of Parliament in 1945 to serve as a national arctic institute, but it has not operated as such for several years.

3. These institutions support a broad range of scientific and research activities in the Canadian North, in the international North and, to a limited extent, in the south polar regions. Canada has developed internationally recognized expertise in many individual areas of northern scholarship and research, and in some areas of polar technology development we lead the world. Several schemes exist to support and train students in northern science. The

Working Group did not find any evidence to support the simple assertion that there are not enough institutions or individuals engaged in polar research in Canada.

4. Despite the number and diversity of the institutions and individuals engaged in polar research, the Working Group found an acute and pervasive sense of dissatisfaction within the polar research community respecting the collective quality, relevance and coherence of polar research in Canada. There are many areas of northern and polar knowledge of importance to Canada where our scientific activities and expertise are weak, and some of the research we are carrying out is not effective. Dissatisfaction is felt equally strongly by those groups who seek to benefit from the results of polar research, including northern residents, industry and national policy-makers.

5. Many scientists and researchers engaged in polar research in Canada work in relative isolation, or feel that they are ignorant of the activities of their colleagues. Northern scientists in Canada are often expected to be general experts on the North, yet they are often poorly informed about general northern developments outside of their fields of expertise, and about polar research activities outside of Canada.

6. Most private and public Canadian institutions and agencies formally engaged in polar research are small and depend upon one or two key individuals for their initiative and effectiveness. The institutional diversity of Canada's polar research community is, in many ways, an asset; nevertheless, there is a serious, debilitating, lack of contact, co-operation and interaction among the members of the Canadian polar research community. In many subject areas, the quality, maturity and sophistication of Canadian research in the polar regions suffers as a result of the absence of a "critical mass" of expertise necessary to generate first class science and research.

7. The direct and indirect support by the federal government of polar science and research has declined in net terms since the early 1970's. During this period, the federal government appears to have re-directed much of its support from long-term, sustained research and systematic data-gathering to the resolution of urgent short-term policy and political problems associated with non-renewable resource development or surveillance for defence. There is a chronic shortage of funds to support polar research in Canada, and there has been a serious decline in the infrastructure (libraries, information systems, research stations) needed to support such activities. This has compromised the sophistication, competitiveness and creativity of Canadian polar research.

8. There is little evidence of any collective sense of purpose or direction within the federal government as a whole respecting the promotion, support, and undertaking of activities to increase knowledge of the polar regions.

9. The lack of cohesion with regard to polar responsibilities within the federal government and the remoteness of the polar research community from decision-makers in government, contribute to much inefficiency in Canadian polar research. Among the consequences have been simplistic and inconclusive "short-order" science and research, and a collective national research effort that is often far removed from the development of policies and the implementation of national objectives in the polar regions. In this respect Canada compares unfavourably with other polar nations.

10. There are many views within and outside of the federal government as to what the role of the federal government should be in polar research in Canada, and little consistency of linkage between the support of research, the research results, and government policies affecting the North. The Working Group concludes that, as the

forces driving Canada's needs for knowledge of the polar regions in the coming years are not likely to be mainly economic, but **are** likely to be of national as well as of regional or local concern, there is no body other than the federal government in Canada with the capacity or mandate to ensure that the necessary research is undertaken.

11. Although the lack of financial support for specific northern studies is unfortunate, the past failure of federal governments to **sustain** their commitments to polar research and to maintain consistent policies respecting the need for, and growth of, knowledge of northern and polar regions is the most serious single cause of the deterioration of polar research in Canada and the basic facilities and expertise needed to support such research. The political and administrative horizons of federal governments in the North have been too short and too fragmented to sustain a commitment to the long-term studies needed to obtain the thorough polar knowledge that will be needed in the coming years.

12. Canada no longer has an outstanding, comprehensive, up-to-date polar library, nor does it have a comprehensive, modern, multi - disciplinary information system supporting polar research activities. It does not have a systematic repository of information on polar research outside of Canada. It does not have a point of contact for Canadian polar scientists, for northern Canadians, the general public and the international polar research community. It does not have an institution or body mandated to be a source of publicly accessible information on the Canadian North and other polar regions. It is particularly difficult for northern residents to obtain reliable information about polar regions and activities. These are serious, glaring omissions in our national polar science structure that affect the quality of polar research in Canada and the level of knowledge and interest in polar matters among the people of Canada.

13. In the past, most science and research in the Canadian North has been undertaken or sponsored in a spirit of discovery and

exploration, to address or respond to the challenges of resource development, or for military reasons. In future years, the issues driving Canadian needs for knowledge in the polar regions will be: the enhancement of Canadian sovereignty; national security; social and economic pressures on a rapidly growing northern population; arctic and global environmental quality; changes in wildlife habitat; the assumption of greater political authority by northerners; the concerns of non-northern public interest groups; and the need to have scientific knowledge from polar regions to address national and global problems.

14. The priorities, goals and methodologies of science in the polar regions are changing rapidly, along with changes in world science. Scientific knowledge important to the local or national issues of the North cannot be obtained through studies in northern regions alone. Research in the polar regions is an essential part of major regional and global research programmes in the physical, biological and human sciences. New technologies have particular application to research in northern and polar areas, and personal computers and advanced information systems make data and results accessible to northerners as well as scientists throughout the world. The natural characteristics of the polar regions and the nature of northern issues mean that important science is interdisciplinary and international to a greater degree than that in most regions of the world. Modern science in the Canadian North must be more quantitative, technology-oriented and integrated with science elsewhere, and at the same time more directly involved with, or part of, local concerns. The existing Canadian systems of support and priority-setting for northern research have not kept pace with these revolutions in polar science.

15. The protection of Canadian sovereignty in the Arctic will be aided by ensuring that we have sufficient scientific and technical knowledge and capability to anticipate, meet and respond to possible challenges, and by maintaining a general international reputation as a world leader in polar science.

16. At the same time that Canada's support for polar research appears to be declining, the support for polar research in other Arctic and sub-Arctic nations such as the U.S.A., Germany, Norway, Japan and Sweden is increasing. These countries are developing new co-ordinated polar science programmes, often with substantial investments in modern facilities and technologies. While definitive comparisons are difficult to make, there appear to be closer working relationships between the polar research communities in these nations and decision-makers in their respective governments responsible for defining and attaining national objectives in the polar regions. These countries appear not to be motivated mainly by the hope or promise of short-term economic gain in the polar regions. Canada's participation in international scientific co-operation in the polar regions is sporadic and under-funded in comparison with that of other nations, and failure to sustain a comparable effort and to participate in our co-operative activities with these nations compromises our self-assertion and influence as an arctic nation.

17. Canada is the only northern circumpolar nation that does not adhere to the Antarctic Treaty nor participate formally in scientific investigations in Antarctica, and this presents a handicap for Canada's own northern interests. It excludes Canada from the general scientific community of polar nations, and allows other countries to take the initiative in setting priorities for international polar studies vital to the Canadian north.

18. Northern Canadians, particularly northern aboriginal people, are alienated from and resentful of much of the polar research that has been and continues to be conducted in northern Canada. The contribution of the polar research community to the resolution of the problems of northern society is insufficient and there is little sense of accountability to northerners by those supporting science or setting its priorities. Although research in the social

and human sciences is belatedly increasing, many northern residents remain suspicious of studies in which they are objects and not participants. Northern territorial governments and native corporations are beginning to establish and develop their own research bodies and activities, but most of these remain operationally and intellectually isolated from the mainstream of polar research in Canada.

19. Despite the laudable accomplishments of several individual scientists and researchers who have established a good rapport, the general attitude of northerners toward the Canadian polar reseach community is one of suspicion, alienation and resentment. The interest and commitment of northern society to much current polar research is slight or in some cases negative. The support of northern-based and indigenous research institutes, and other measures designed to increase the accountability to northern concerns of polar research in Canada should be priorities for any federal policies on polar research.

20. Problems as diverse and deep-seated as the fragmentation of polar research in Canada, the need for greater involvement of native northerners in polar research, and the challenge of increased international activity in polar regions do not lend themselves to a single solution. They cannot be addressed effectively by a single institution or authority. There are already in Canada a considerable number of institutions attempting to deal with these issues. What is needed is not another research institution, but changes that will support the institutions already in place and give their work increased effectiveness and coherence.

21. New Canadian structures are needed, not to undertake or manage research in the polar regions, but to support existing and emerging Canadian institutions engaged in polar research. These structures should be constituted to address specific needs not currently satisfied by the present situation and specific problems currently facing the Canadian polar research community.

22. Therefore, the Working Group recommends that :

a) steps be taken to create a standing Canadian Polar Research Commission, accountable to the Canadian government at a senior level and responsible for monitoring and reporting on the needs and progress of polar sciences and research in Canada, both governmental and non-governmental, for recommending steps to be taken by the federal government to improve the relevance and effectiveness of Canadian activities in polar science, and for facilitating international and domestic liaison and co-operation in polar research. The Commission should be composed of knowledgeable and experienced individuals from both in and outside government, and should include a substantial number of northern residents;

b) steps be taken to establish, in conjunction with the National Libraries and with provision for continuity, a comprehensive Canadian Polar Information System. The System should incorporate or support existing data and information systems, be compatible with national and international scientific data systems, and be easily accessible to northerners for practical use. The system should be a general repository of national and international information on the polar regions;

c) steps be taken to establish a physical institution in the National Capital Region, here called "Polar House", to serve as a tangible expression of, and public contact point for, Canada's polar and northern interests and to foster development of a cross-disciplinary "critical mass" of northern and polar expertise;

d) the federal government increase its efforts to promote the greater involvement of northern research institutions and northern Canadians in the determination of national priorities for polar research and the actual undertaking of polar research in Canada. Specifically we recommend increased financial and other support for northern institutions engaged in research activities in the North, the effective participation of northerners in national institutions concerned with polar research, and measures to facilitate the access of northerners and northern institutions to the Canadian Polar Information System;

e) a national polar science communications centre be established, as part of "Polar House" and drawing on the Canadian Polar Information System, to provide to the Canadian public and interested persons from other countries information about the Canadian North, the polar regions, and Canadian polar science;

f) because of the increasing national and international importance of scientific knowledge of northern Canada and the polar regions, the federal departments engaged in scientific activities in the North give greater emphasis to their northern research, and co-operate with the Canadian Polar Research Commission in determining scientific priorities and the most effective scientific activities in their areas of responsibility.

1. INTRODUCTION

Canada is a northern nation whose prosperity and social well-being depend to a large degree on advances in scientific knowledge and continuous improvements in technology. Two-thirds of the country has a natural environment which is "arctic" by any common definition of the term. Both the indigenous societies of the North and the mainstream Canadian society have developed life styles and economies based on their response to, or knowledge of, northern or arctic conditions and resources. The defence of Canadian sovereignty, national security, the efficient and responsible management of Canadian resources, the protection of the environment and natural amenities, the quality of housing, communities, transportation systems and communications essential to a good life for all Canadians depend directly on our knowledge of Canadian northern conditions and our ability to adapt scientific advances, technologies, commodities and management systems from other parts of the world to the Canadian natural and social environment.

Canada shares with other polar nations the problems and opportunities arising from our northern geography and arctic history. Among the world community Canada, as a technologically developed country, has the capacity and the responsibility to provide knowledge from high latitudes which is important to the world. For these reasons, and because of the need to ensure that all Canadians, wherever they may live and whatever cultural background they may belong to, are able to participate in all aspects of Canadian life, and to share in the responsibility for its development and benefit from its prosperity, the continued development of scientific and technical knowledge related to the North and the polar regions is very important to all of Canada.

The world of science transcends political boundaries. But the scientific knowledge that is vital to Canada in respect to its northern and polar conditions and issues cannot always be imported from other countries, because other countries do not have the same conditions and needs. There is much that we can learn from and share with other circumpolar nations but Canada's needs for northern and polar scientific knowledge must be met principally through research and study by Canadians, supported by Canadian institutions.

Science in northern Canada has played a significant role in world science since the earliest explorations of the polar regions. Canadian science in the Arctic has made important, in some instances essential, contributions to the well-being of all of Canada and of the world. On the whole, however, Canada has been a user rather than a producer of polar knowledge. The polar regions provide Canada with opportunities to develop new knowledge, improved technologies and a better ability to sustain the harmonious socioeconomic development of the Canadian North. Such knowledge is also of value in enhancing Canada's international relations and influence.

This report presents the results of a personal investigation by four people into the state of science with regard to northern Canada and the polar regions.

2. THE WORKING GROUP AND ITS ACTIVITIES

2.1 Origin and First Steps

On 19 September, 1985, at the Arctic Policy Conference held at McGill University, the Honourable David Crombie, then Minister of Indian Affairs and Northern Development, announced that he had asked a small group of people to "make recommendations concerning the setting up of a National Polar Institute for Canada".

He stated :

> "We must develop a new, effective, world-class focus for our network of northern science and education; one which will work with our northern territories and their people, one which will bring together university, college, government, private sector bodies already in the field and which will become **the** point of contact for other circumpolar countries and agencies."

At the request of the Minister, the four people designated formed an informal Working Group with the following terms of reference :

"A. Review the present situation in Canada concerning scientific activities, accessibility and dissemination of information, contacts and exchanges related to northern Canada and polar areas generally, to assess the adequacy of present institutions and arrangements and to identify areas where improvements are most needed. Particular attention should be given to :

(i) the informational and research needs, and involvement of northern residents in arctic scientific activities;

(ii) the transfer of basic scientific knowledge from arctic research to industrial and policy applications; and

(iii) the effectiveness of present institutions in support of Canada's international role in polar affairs.

B. On the basis of the review undertaken in item A, consider the need for and advisability of establishment of a national institute, body or organization in Canada to supplement, support or improve upon the existing institutions concerned with northern or polar affairs.

C. Consider the nature, structure, general mandate and function, and accountability, of alternative ways of meeting the perceived needs, and the preferred location and approximate cost of the action recommended.

D. As appropriate, consult with agencies and persons in the federal, territorial and provincial governments and non-government agencies directly concerned with arctic science, on any of the above topics, and including research priorities in natural, social and applied sciences, arctic and polar information and international relations."

The Working Group divided its task into several phases :

(i) It undertook a review of the present institutional arrangements for the support of northern and polar science in Canada, of the facilities for research, scientific information assembly and transfer, and for the access of the general public, northerners, the academic community, industry, and government agencies to northern and polar research in Canada;

(ii) It solicited a wide range of views. A general letter (Appendix A) outlining the study, and asking for comments and recommendations, was distributed to about 800 individuals or groups using the mailing lists of the

Association of Canadian Universities for Northern Studies, the Canadian Arctic Resources Committee, and the departments of Indian Affairs and Northern Development and Environment Canada.

(iii) Members of the group met or communicated directly with individuals, organizations and institutions in the North, as well as many in southern Canada who had northern concerns or activities, and discussed with them their perceptions and suggestions about northern and polar science in Canada.

(iv) A review was made of the "polar institutes" or their equivalents that have been established in other countries, including their terms of reference, support arrangements, scope and scale of work. Discussions and correspondence were initiated with individuals in other countries, in order to learn of their experiences with the kinds of institutional support for northern science in their respective nations (Appendix B).

(v) Polar science in Canada was considered, both in relation to its adequacy to meet Canadian needs in the North, and in relation to the progress of national circumpolar and world science. An assessment was made of the likely future trends and directions in polar science as a background to anticipated needs for science support and coordination in the near future. We were aided greatly by reviews of polar science needs and priorities undertaken recently or currently being conducted by other agencies in connection with Beaufort Sea development, U.S. arctic policy, antarctic science, the Nordic Council, the Comité Arctique International and the Canadian Committee for the International Geosphere-Biosphere Programme.

(vi) A selective review was made of the past and present development of various institutions and mechanisms designed to facilitate and co-ordinate northern and polar research in Canada since 1945 (Appendix C), and of different proposals made and actions taken for the support, co-ordination, or improvement of northern science and research in Canada. Of particular assistance in this connection were the publications and submissions of the Arctic Institute of North America, the Advisory Committee on Northern Development, the Association of Canadian Universities for Northern Studies, the Science Institute of the Northwest Territories, the Science Council of Canada, the Northern Scientific Training Program, the Polar Continental Shelf Project, the Arctic Petroleum Operators' Association, and the recent Special Joint Senate and House of Commons Committee report, Internationalism and Interdependence.

(vii) Finally, the Working Group prepared this report. The Working Group was assisted by Mr. Kenneth de la Barre, who analysed the written submissions and the notes of various meetings, and who compiled the initial drafts of several sections of this report. We are grateful to the Circumpolar and Scientific Affairs Directorate of the Department of Indian Affairs and Northern Development and its Director, M. Donat Savoie, who arranged the financial and administrative support we required. We also thank Mrs. Lucille Baker of Environment Canada, Mme Paule LaMarche of Makivik Corporation and Mrs. Eileen van Heyst of ACUNS for their patience and co-operation during hours of typing and re-typing.

2.2 Premises

After receiving our terms of reference from the Minister of Indian Affairs and Northern Development, the Working Group agreed on the following general guidelines for our work :

A) although we would have to bear in mind the current fiscal situation and the practicality of new government activities or programmes in the near future, we would focus primarily on what Canada needs, and what would be most effective within the Canadian political and social structure. We would not address the question of how to find new funds for northern science or attempt to guess a ceiling on costs, but we would be realistic about costs in all recommendations;

B) the general time frame for our considerations would be the next decade. We would be concerned primarily with what institutional support Canada should have in place several years from now, when science is likely to be evolving in new directions, but not so far in the future that economic and social needs and the structure of science bear little relation to the present. Although our recommendations might include matters for immediate attention, our main concern would be with how to get from the present to where we believed Canada should be with respect to polar science in ten years' time;

C) our concern would be primarily with science and scientific knowledge, widely defined. We would be aware of but not explore in detail the issues and policies that create demands for science or make use of its results. We would be concerned with all aspects of knowledge dealing with the phenomena of northern Canada and the polar regions, both Arctic and Antarctic. "Northern regions" would be taken to include those parts of Canadian provinces where distinctive arctic and subarctic conditions prevail.

2.3 Information and opinions

A flood of information was received in response to our letters soliciting opinions and recommendations. It was quickly apparent that the organization and the support of northern and polar science in Canada is of great interest within government, academic and industrial circles, and to northerners. More than 250 briefs and letters were submitted. The written briefs varied from one-page letters to twenty-page formal essays. Many briefs represented a group consensus; others were highly personal, often heartfelt contributions. The Royal Society of Canada, the Association of Canadian Universities for Northern Studies, units of the Department of Energy, Mines and Resources, and some university departments held special meetings to discuss the issue, and we received, in several instances, successive briefs from the same individual or group, reflecting an evolving consideration of different aspects of this important matter.

The members of the Working Group, together or individually, attended about forty meetings to discuss a national polar institute for Canada. Several of these meetings were held in the Northwest Territories and Yukon, in February and in April, 1986. Discussions ranged from formal sessions with federal and territorial government officials to symposia with scientists at the local pub. There were meetings with northern aboriginal groups, with school teachers and the staff of northern colleges, with citizens' action organizations, and with officers of northern businesses and industrial associations. Some meetings were confidential, and we heard many contradictory or irreconcilable opinions. These meetings were particularly useful for exchanging ideas on the social and managerial problems, which are difficult to cover in written submissions. Almost everywhere we encountered openness and frankness, a generally constructive if sometimes skeptical attitude, and a sincere concern about the future well-being of science in the Canadian North.

Through personal discussions, visits, and correspondence, comments and suggestions were received from persons connected with polar institutes or their equivalents in the United States, the United Kingdom, Denmark and Greenland, Sweden, Finland, Norway and Japan. The issue of a Canadian polar institute was discussed informally by international groups of polar scientists at two meetings connected with the Antarctic Treaty, and at meetings in Norway and Finland concerned with international research on the Arctic Ocean.

The Working Group is grateful for the thought and care that these individuals and institutions devoted to this question. The breadth and depth of the responses showed that it was timely and important to consider the organization and co-ordination of northern and polar science and research in Canada. They showed as well that the problems are extremely complex and touch many aspects of the general state of Canadian science and the rapidly changing Canadian North, and the evolution of world science.

Most of the submissions favoured the idea that a national polar research organization would benefit Canada, provided that it did not threaten or lessen the effectiveness of the many existing organizations and institutions active in northern science. However, there were few coherent views and no widely shared consensus on what a "polar institute" ought to be. There was a range of differing opinions on what was and was not likely to be successful in Canada, given both the lack of success in maintaining an effective national institute in the past and the likely financial, institutional and political realities of the next decade.

In preparing the report and recommendations that follow, we considered the many suggestions and opinions we received and studied the analyses and summaries presented to us. But we have not in any way attempted to present a summary or common denominator of all the advice we have received. Our recommendations are the personal views of four people, each with extensive but very different northern or polar experience, who have not always seen eye to eye but who share a common interest and concern for the matters discussed herein. After much discussion, we agree on all main points and respectfully present this joint personal report for the consideration of the Minister and the interested Canadian public.

3. THE PRESENT SITUATION

3.1 An Overview of the Present Organization of Northern Research in Canada

Polar research activities in Canada are conducted and sponsored by a wide range of institutions and organizations. The following are some of the key organizations and their main interests and responsibilities. An awareness of this complex situation is essential background to the review of northern or polar science in Canada.

3.1.1 Government activities

Within the federal government the **Department of Indian Affairs and Northern Development** (DIAND) has a legal mandate to foster, "through scientific investigation and technology, knowledge of the Canadian north and of the means of dealing with conditions related to its further development"[1], and it is structured to provide an organizational framework within government for the planning, implementation and support of northern research, technology and education. In addition, about **twenty other federal government departments** or agencies have nation-wide mandates under which they carry out technical, scientific, and/or knowledge gathering activities in northern, arctic or polar areas. In practice, these departments or agencies carry out their northern work essentially independently, except where co-ordination of logistics is advantageous. In the past ten years little use has been made of the government-wide framework available through DIAND for planning and co-ordinating research and northern information.

Precise figures on the amount of northern science conducted or supported by the federal government are not possible to obtain because it is in many cases not practical or desirable to separate "northern" science from science of a national scope that includes the North, or to separate

---

[1] DIAND Act, section 5(d)

"science" from other activities that may include research and development or scientific information, or because definitions of what is "northern" vary from subject to subject and according to the time or purpose of the study. About sixty percent of activities in northern or polar regions that can conventionally be called Research and Development or Related Scientific Activities as defined by the Ministry of State for Science and Technology is estimated to be spent by five departments; **Communications; Energy, Mines and Resources; Environment; Fisheries and Oceans;** and **National Defence.** Another twenty-five percent or so of federal northern science is undertaken or supported by the Departments of **Agriculture; Indian Affairs and Northern Development; National Health and Welfare; National Museums of Canada; the National Research Council; the Natural Sciences and Engineering Research Council; the Social Sciences and Humanities Research Council;** and **Transport.** Some excellent research and scholarly study related to the North is also carried out from time to time by **Canada Council; Employment and Immigration; National Energy Board; National Library and Public Archives; Secretary of State;** and **Statistics Canada.**

Among the institutions and facilities devoted to support of northern science, the **Polar Continental Shelf Project** of the Department of Energy, Mines and Resources provides logistical support and operational co-ordination to the scientific activities of federal agencies, universities, investigators from territorial, provincial and foreign agencies and to the private sector for research and survey programmes in the Arctic Islands, adjacent waters and the northern mainland. In each of 1985 and 1986, about 220 field projects, or more than half of all scientific activities supported by the federal government in the high Arctic and Arctic Ocean area, have been supported or co-ordinated by the "Polar Shelf". Its budget is entirely devoted to the increase of publicly available scientific knowledge of the polar regions.

Simple laboratories and operational field bases, the **Northern Scientific Resource Centres,** have been built by DIAND at Inuvik, Igloolik, and Iqaluit, and are available to all bona fide researchers. Other federal departments maintain northern field stations or research centres that can at times accommodate compatible research from other agencies. The arctic weather stations of the **Department of Environment** and the northern research laboratories and vessels of the **Department of Fisheries and Oceans** are examples.

The territorial governments undertake a variety of scientific information, research and educational activities. The Northwest Territories legislature has established a formal organization - **The Science Institute of N.W.T.** - with responsibilities for developing an indigenous northern scientific community and for providing advice to the Government of the Northwest Territories on scientific matters. Proposals for a similar institution in Yukon have been under discussion for several years.

Important scientific activities, particularly in support of economic and resource development and in the social sciences, are undertaken by provincial governments in the northern parts of several provinces. Some provinces have departments or agencies dedicated to northern matters, and some of these maintain important scientific units or facilities. The **Churchill Northern Studies Centre** operated by the government of Manitoba, the local community and universities is a leading example.

An Act of Parliament in 1945 created **The Arctic Institute of North America** and charged it with the responsibility to acquire and disseminate information about northern and Arctic regions, to provide advice about the North to the government of Canada and to individuals and organizations, and to sponsor and undertake research and to assist in the orderly development of the Canadian North (Appendix D). Although the Act remains in force and the Institute continues as a centre of arctic information and expertise, it has not acted as a "national" institute for some years, and has not received Federal core funding since 1976.

3.1.2 Non-government activities

Over thirty-five Canadian universities have identified programmes of northern research, training and education. Six of these maintain specialized continuing research centres or institutes and/or have field research facilities in the North. Some of these centres or institutes are as large and comprehensive as the national polar institutes of other Arctic countries. The universities support an umbrella-type association, the **Association of Canadian Universities for Northern Studies** - that coordinates and disseminates information and acts as spokesperson for common university interests in the Arctic. Universities also have formed other scientific institutions, often in association with industry - e.g. the **Centre for Frontier Engineering Research** (C-FER) - to promote co-operation in northern research or to develop centres of expertise and specialized facilities.

A number of industry or joint industry/university organizations and institutes have been created to facilitate co-operation, the exchange of information and the planning and conducting of research as applied to industrial activities in northern Canada. The **Arctic Petroleum Operators Association** (now amalgamated with the Canadian Petroleum Association), and the **Centre for Cold Ocean Resources Engineering** (C-CORE) are two industry-led organizations that have been world leaders in the research and development of polar technologies.

A few northern businesses and native development corporations have developed their own important research programs. **Makivik Corporation** of Kuujjuaq, Qué. is perhaps the leading example. One private organization, the **Arctic Research Establishment** at Pond Inlet, N.W.T., has carried out research, data gathering and technology testing in the Arctic over the past thirteen years to increase northern knowledge and to develop practical scientific knowledge and technical expertise among northern residents.

Several citizens' groups and native political organizations are engaged in, or support significant northern research in their respective area of concern, and contribute importantly to the knowledge of the North and to scientific literature. The **Canadian Arctic Resources Committee, the Council of Yukon Indians** and the **Grenfell Association** are three influential examples. An indication of the level and diversity of activity in Canadian northern science is given by the fact that more than 50 active field stations are listed in Canada's Northern Stations (ACUNS, 1986).

3.2 Canada and Polar Science

Canada is active in a number of scientific activities of a circumpolar or bi-polar nature. These are generally of two types : (i) global or broad regional programmes in which research from other arctic areas or from the polar regions is important to general scientific understanding or the programme objectives; and (ii) natural extensions of Canadian scientific interests, expertise or technology, as Canadian scientists pursue their research wherever the evidence or scientific challenges lead them. In the polar regions, as elsewhere, scientific problems transcend political boundaries, and the pursuit of science important to Canada will involve research in other polar regions. As a scientifically advanced country and one that has developed considerable polar scientific expertise and technology, Canada both profits from and contributes to circumpolar and bi-polar research.

Canadians are active members of a wide range of important international, arctic or polar scientific activities. Examples of these are : the **Polar Research Board** and **Polar Oceans Panels** of the **U.S. National Academy of Sciences; Comité Arctique International;** the Northern Science Network of the **UNESCO Man and the Biosphere Programme;** the **Arctic Ocean Sciences Board;** the **International Permafrost Association** and the **Northern Libraries Colloquy.** In these and many other examples, the participation is arranged on an individual or agency-to-agency basis, and justified on the basis of its individual value to the Canadian programme concerned. The Canadian government has not generally felt a need for national co-ordination or a national policy respecting international polar research activities.

3.2.1 North polar regions

Since the International Polar Year, 1882-83, when eleven nations sent simultaneous expeditions to the Arctic and sub-Antarctic (five of them to northern Canada), international co-operation and co-ordination have been a feature of polar science. Canada has co-operated in many subsequent international global or circumpolar research programmes, such as the Second International Polar Year, the International Geophysical Year, the International Hydrological Decade, the International Biological Programme, and the several specialized or continuing successors to these. Canadians have been active in the Circumpolar Health Conferences, the Polar Bear Convention, the Polar Sub-Programme of the Global Atmospheric Research Programme and its successor, the World Climate Research Programme and many others - the list is as extensive and varied as subject areas of scientific interest in polar regions.

Canada's total activity in basic research in the polar regions is, in comparison with the extensive proportion of the circumpolar Arctic that is occupied by Canada, quite modest; but Canadian links to and influences on international or world research programs involving the polar regions are extensive. Those links and influence are due to the efforts and contacts of individuals rather than a formal national policy or deliberate commitment of funds in support of a general national priority. In fact, there is some evidence that a factor encouraging Canadian northern scientists to be active in international polar affairs is the difficulty in obtaining support for domestic northern science; by developing active co-operations with other countries, it has been possible to advance scientific knowledge in areas of interest to Canada at less cost. It may also have been easier to persuade Canadian authorities to support the Canadian portion of international co-operative research than to get support for the same work done unilaterally in Canada.

Canada has included collaboration or co-operation in scientific activities in polar regions in a number of bilateral agreements. Intergovernmental agreements with polar nations that specifically provide for co-operation in research and the sharing of technical information include those with **Denmark, Norway** and the **USSR** . Bilateral agreements for co-operation in science that include polar research have been signed with **Brazil, Federal Republic of Germany** and the **United Kingdom** . With several other countries, such as **Australia, India, Japan, New Zealand** and the **U.S.A.,** agency-to-agency discussions have involved the exchange of polar research information and research plans, and discussions on the suitability and availability of Canadian polar technology.

3.2.2 South polar regions and bi-polar studies

Individual Canadians have taken part in research in Antarctica for the last 70 years, but in small numbers and usually as part of the expeditionary activities of other countries. Canadian government scientists played an active part in planning the science programme in Antarctica for the International Geophysical Year (1957-58), but Canada's own field researches on that occasion were limited to the Arctic. The Canadian government ship **Hudson** made important contributions to antarctic oceanography during its circumnavigation of the American continents in 1970. A number of Canadian federal departments - Communications; Energy, Mines and Resources; Environment; Fisheries and Oceans; National Museums - have supported scientific work in Antarctica through assignment of scientific personnel to antarctic field studies, or by the provision of specialized scientific equipment such as the Canadian oceanographic/meteorological drifting buoys deployed in the Southern Oceans during the International Indian Ocean and Southern Ocean research programmes. Areas of antarctic research that have been identified as particularly pertinent to Canadian science include ionospheric and upper-air studies, atmospheric chemistry, air-sea-ice interactions and their effect on marine life, tectonic and climatic history, glaciology of continental ice sheets, palaeozoology, endolithic organisms, and polar physiographic processes. In these and other areas, Canadian research on arctic problems is incomplete or made more difficult without complementary or supportive studies in southern polar regions, and it has been found to be in Canada's interest to participate in antarctic research to increase the benefit and relevance of such studies. In some subjects, such as ionospheric or planetary magnetic phenomena, the research is genuinely bi-polar, with simultaneous observations in Antarctica and at the geophysical counterpart or "conjugate" point in northern Canada.

Except for the cruise of the **Hudson** in 1970, there has not been an official wholly Canadian-sponsored scientific activity in the southern polar regions. The number of Canadians working in Antarctica, as part of the programmes of other nations, but in many cases carrying out work that is an extension of research in Canada, has never been large - two to eight per year in the past decade. But some have been international research leaders or have played prominent roles; the scientific leader at the South Pole during 1984 was a Canadian geophysicist.

Canadian commercial technology, developed and proven in arctic service, has found a ready market in Antarctica. More than a dozen countries undertaking scientific work in the south polar regions make extensive use of Canadian prefabricated housing, over-snow vehicles, polar clothing, ice drills, STOL aircraft and their crews, airborne remote sensing, photographic and geophysical services adapted for high latitudes, icegoing supply vessels and crews, etc. These activities in turn have increased Canadian technical polar competence and experience.

3.3 A Time of Change

Considerations of the adequacy and effectiveness of scientific activities and organization related to the Canadian North and the polar regions generally must include an awareness of the rapid and profound changes taking place in northern Canada and in all polar regions.

Social, economic, political, scientific, and conceptual changes are resulting in a "North" and a "Polar Concept" that are fundamentally different from those in which most of our present scientific knowledge was developed and for which most of our government or educational structures were designed. Because of these changes, there will be different expectations and needs for science than those that have been dominant in the past three decades.

The Canadian North and the polar regions are not the only parts of the the world where rapid and fundamental change is taking place. Accelerating change is a feature of all aspects of human society. The natural physical and biological environment is also changing noticeably within our lifetime. But there are some aspects of the changes that are occurring in the polar regions that are distinctive, and which will affect the purpose, content and style - and lead to different practitioners - of Canadian scientific activities in the near future. The Working Group was made very aware of these changes. This report will not attempt to probe into their causes, or detail their characteristics, but the following are some of the changes that will have an important effect on Canadian northern and polar science. None of them is unique to the North, but collectively they serve to increase, not decrease, the differences between northern regions and the rest of the country.

3.3.1 Changes in the Canadian North

Social: the increasing socio-economic influence and political consciousness of northern native peoples; a greater awareness of distinct cultural differences between groups of northern peoples, as well as between northerners and southern Canadians; and attendant expressions of alienation, such as latent rebelliousness, passivity, unco-ordinated attempts at inter- cultural bridging and generation gaps.

Economic: very large costs and budgets for most northern activities; a badly fitting overlay of the wage economy on the traditional non-monetary economic structure; increased dependence on centralized support with erosion of the accepted obligation of a region or its people to pay back from locally generated wealth; an increasing pressure on large-scale industrial enterprises to justify investments in the short-term; the increased influence of national policies and international politics in resources and transportation developments; declining economic opportunities for a rapidly expanding northern aboriginal population.

Political: progressive advances in the self-determination and self-expression of northerners, not related to population numbers or their financial tax base; an increased regionalization of expectations and actions within the North and a simultaneous desire of southern Canadians and governments for uniform and consistent northern policies; the increasing international influence on Canadian northern affairs; the increasing importance of military and strategic factors in northern policies.

Scientific: in the natural sciences : an increasing need for understanding of key natural processes, rather than descriptive data and surveys to provide information on the location and nature of resources; concern with the environmental consequences of human activities, and the effects of major or regional events like climate change or alteration of ecosystems; the increasing importance of polar science to major international or global interdisciplinary studies; new techniques of remote sensing, quantitative analysis, mathematical modelling and data handling leading to profound changes in the methodologies of polar regions field studies. In the medical sciences : advances in understanding of genetic development, physiological adaptation to stress, and of psychological responses in different environments leading to research challenges and fields of study related to health and social behaviour in the distinctive northern environment, the consequences of the rapid transition to a variety of workplace environments, and the effects of changed lifestyles and diets. In the social sciences, the intermixture and contacts between indigenous low energy and imported high-energy technical cultures; the cultural effects of rapid physical transformations of almost all northern settlements and progressive introductions of modern technologies to northern life; the growth of guaranteed rights and freedoms with a paradoxical difficulty in exercising them for economic, cultural, environmental, and historical policy reasons; the application of a legal system that was developed in a different historical and social context; the dilemmas of northern education and justice.

3.3.2 Circumpolar, bi-polar and international developments

Changes of the kinds noted above have been experienced by most circumpolar nations, with the result that despite important national political, economic and cultural differences, the "northern" issues of public policy arising in arctic countries have many similarities. In many areas there is more in common between arctic regions of different countries than between the arctic and non-arctic parts of the respective countries themselves. As the resolution of these issues and the adjustment to change depend upon increased and coordinated scientific knowledge, the circumpolar countries have experienced profound changes in their needs and priorities for scientific study in recent years. The international aspects of polar science are therefore changing, along with social, economic and scientific changes.

An additional important feature of the changing international situation affecting polar science is the renewed and changing interest of non-polar countries in scientific studies of the polar regions. In recent years, the emphasis in science has shifted from a pursuit of knowledge to science as a technical tool for solving national or economic problems, and there has been a resurgence among non-polar countries with a polar science tradition in polar science for what appear to be nationalistic or utilitarian purposes. In countries such as the U.S.A., Sweden, Norway, Germany and Japan, existing polar research organizations have been strengthened, or new ones established, in the last decade. The result has been an increase in total polar science and research capacity, the greater involvement of non-polar countries in research in the polar regions, and a wider recognition of the national and international importance of scientific knowledge and research activities in the polar regions.

This surge of interest among non-polar nations is particularly evident with respect to Antarctica, where, under the Antarctic Treaty System, territorial claims are held in abeyance and all participating nations agree to co-operate openly and share or exchange scientific information. An international regime - the Convention for Conservation of Antarctic Marine Living Resources - has been signed and ratified for the management and conservation of renewable resources, and a similar regime for the management of mineral resources is nearing completion. While some of the recent interest in participating in antarctic science may be based on a hope or gamble that, at some future date, economically exploitable resources will be found in Antarctica, all geological evidence and economic analysis indicate that there is no realistic expectation of net economic return from antarctic minerals in the foreseeable future. The scientific programmes and policies of the nations that are involved in Antarctica are based on recognition of the benefit and value, to each nation as well as to international relations, of improved scientific knowledge of the polar regions. These benefits are greater knowledge of climate, global changes in the environment, biological and geological processes, and of the solar and magnetic influences on the Earth that can only come from study in the south or bi-polar regions.

3.4 The Driving Forces

Scientific research, geographical explorations, technical surveys and data collection, the development of polar technologies, and specialized engineering in northern and polar regions have been undertaken in the past in response to individual quest for new knowledge, curiosity about little-known lands or peoples, national or personal incentives for discovery, the exercise and strengthening of military prowess, or in the hope of economic profit through trade or resource development. The present scientific knowledge of northern Canada and of polar regions has been acquired largely as a result of these incentives, and our research organizations and present institutes reflect this. The profound changes taking place in the North today reveal that new factors are driving the course of events and, consequently, the need for knowledge. These new, driving forces must be taken into account when considering the organization and structure of Canadian scientific activities in northern Canada and the polar regions in the near future.

3.4.1 The military and geopolitical importance of the polar regions

One of the harsh and inescapable facts of the closing decades of the twentieth century is that the north polar regions are sandwiched between two antagonistic superpowers. On the world stage these regions are important, not for themselves, but for the role they presently or potentially play in separating, hindering or facilitating military and geopolitical strategies. Modern technology has at last made it possible for politicians and strategists to consider the world as a sphere instead of an open-ended cylinder, and operations in, over or through the north polar regions are a part of their day-to-day thinking and planning. This has not only brought new technologies to the North, from the now obsolete DEW line to under-the-ice submarines to advances in satellite surveillance; it has moved many areas of important scientific arctic research away from the influence of organizations and interests primarily concerned with the North to that of interests and organizations concerned with military power and global strategies.

The military importance of the Arctic has increased. The advances in military technology and the geopolitical and geomilitary strategies of the superpowers put the Canadian Arctic in an important and, in the view of some, a vulnerable position. The highly sophisticated science that is integral to any high-latitude military system has resulted in the development of a very advanced and specialized research and technology. In some cases, knowledge of the geophysical and environmental aspects of Canadian arctic land and ocean characteristics has advanced tremendously, even though such knowledge is in the main not available to the public, and even though in some cases the knowledge and control of its use may not be in Canada. One result is that much of the most sophisticated and significant arctic knowledge has become "closed", and inaccessible to exchange among northern peoples and northern scientists at large. Another result has been the development of two systems of priorities and support for northern national and circumpolar science. One is based on domestic needs, regional priorities and the international exchange of knowledge, while the other is tied to military needs and geopolitics. The geopolitical system of priorities is relatively remote from the social, economic and cultural needs of northerners, as has been demonstrated by controversies relating to Cruise missile testing or low-level military flying in Labrador.

Military science engages a comparatively small portion of Canada's northern scientific community, but it is a powerful force behind some international and circumpolar studies of interest to Canada and it can suddenly overwhelm and sweep aside established activities and domestic priorities in the name of national survival and political commitment. In the view of many, the growing national and international emphasis on military-related science in the Arctic makes it imperative that Canada have a strong and comprehensive co-ordinated civilian science program, - one that is geared toward public knowledge and the problems of northerners and northern societies, and which is openly co-operative and internationalist.

Attempts to bridge or reconcile the two systems of priorities and support are characteristic of some of the most important northern Canadian and arctic circumpolar science today. Some research undertaken for military or geopolitical purposes is unclassified, and some open civilian research in oceanography, geophysics, and remote sensing is sponsored by military agencies. International scientific organizations have had considerable success in bringing together scientific information and research activities which are of value to each nation according to their strategic priorities, but which contribute to shared knowledge of benefit to all.

The military and geopolitical importance of polar research has both positive and negative effects. It can distort and, in some cases, severely restrict and hamper free research and exchange of information, but it also facilitates the growth of northern science and its application. It brings to some areas of northern study financial resources and technical sophistication far beyond that which could be expected on the basis of northern priorities alone. Over and above these questions, the geopolitical factors ensure that northern science and technology development play a critical role in the maintenance of world peace, or in national survival in case of a major international conflict.

The Antarctic Treaty has laid to rest some very serious and potentially explosive international conflicts and irreconcilable positions, and over twenty-five years has made scientific partners in co-operative research of nations who, in other parts of the world or in other contexts, are very suspicious of one another. The Treaty is one of the world's most successful examples of an internationally accepted, flexible conflict resolution mechanism, in which a common search for shared scientific knowledge, protection of the environment, and the rational sustained management of common resources take precedence over individual national goals. This, too, is a distinctive aspect of the geopolitical and scientific importance of the polar regions.

Although not yet a signatory to the Treaty, Canada has formally endorsed the Treaty principles at the United Nations and has been active in discussions on the future of Antarctica. Despite the lack of a formal Canadian programme in Antarctica, the activities of Canadian scientists and the success of Canadian technology are natural extensions of the expertise, interests, and commerce developed in the north polar regions, and a demonstration of the fact that specialized scientific knowledge obtainable only in Antarctica is valuable for the solution of Canadian arctic problems.

3.4.2 Sovereignty

Since the voyage of the U.S. Coastguard vessel, **Polar Sea** through the Northwest Passage two years ago, Canadians have been aware that Canada's sovereignty over the waters of the arctic archipelago is contested by the United States and other maritime nations. Since then, arctic sovereignty has been a prominent public issue and a major concern of the federal government, which has announced several measures designed to strengthen Canada's claim. Many have suggested that the scope and quality of Canadian polar research has a bearing on this issue. On October 1, 1986, in the Speech from the Throne, the Government stated its intention to undertake more polar research in order to "support this vital national purpose".

Military and geopolitical aspects of the modern North, as they affect science, were noted in Section 3.4.1. But questions of sovereignty and science involve much more than military strength and operations. The report of the Special Joint Senate and House of Commons Committee on Canada's International Relations, Internationalism and Interdependence draws attention to many issues where increased knowledge of the arctic regions will contribute to Canada's political and economic security, and from that will contribute to the ability of Canadians to control affairs in the North, which is the essence of arctic sovereignty. Indeed, it appears that one of the reasons why the issue of arctic sovereignty has recently assumed great importance, and why the Canadian public has become concerned, is a worry that we do not know as much as we should about our own Arctic, and that actions of other nations, however friendly, will enable them to obtain knowledge about our own country that we do not ourselves possess.

It is difficult to state categorically the degree to which polar research relates to Canada's legal position respecting the waters of the arctic archipelago. However, a strong national commitment to polar science and research is an essential component of Canada's self-assertion as a major arctic nation, and of its determination to exercise all the rights and responsibilities that this entails. Moreover, Canada sometimes asserts the proposition that the physical and historical uniqueness of arctic ice and waters justifies legislative and administrative regimes that differ from those regulating the status and use of other maritime regions. As these arguments are not yet accepted by all members of the international maritime community, it is clearly important for Canada to ensure it has the knowledge of the natural and human characteristics of the region that are necessary to substantiate Canadian claims.

In our view, the most important link between polar research and arctic sovereignty is the degree to which Canada is perceived by the international community as a vigorous actor in the territories it claims, a leading force in polar research, and an active participant in international organizations and initiatives respecting the Arctic. Canada's resolve to exercise sovereignty in the Arctic can be strongly expressed through an outward looking presence that impresses and earns the respect of other nations engaged in polar research, some of whom carry considerably more military and technological might than Canada.

3.4.3 The dwindling of economic prospects

From the time of Martin Frobisher, business interests and governments have invested in the exploration and study of the Canadian North with the hope and expectation that the resources of the northern regions would provide substantial new wealth in the form of profits or taxes. There has been a persistent belief, almost always running ahead of the evidence, that somewhere in that vast region there were treasures which could bring great financial reward, or that the development and operation of major arctic trade routes would lead to commercially important enterprises.

Much of our scientific knowledge of the arctic regions of North America, and almost all of the modern development of non-military, specialized northern technology, have been tied to hopes of commercial development and resource exploitation. Yet, despite four hundred years of repeated and imaginative investment and effort, these hopes have rarely been realized. In only three major enterprises has investment in northern Canada produced important net profits on a national or international scale : the northern fur trade from 1670 to about 1920; whaling in the nineteenth century; and mineral development in the Yukon 1898-1910. The first was based on a modest but sustained development of a renewable resource. It depended on indigenous knowledge of natural history and the development of trading and transport patterns that, for commercial reasons, did not disrupt the northern environment or attempt to achieve economies of large scale. Although the fur harvest was maintained, the activity ceased to be profitable on a net national basis when social development and population increases in the North required public investments greater than the taxes derived from fur industry profits. The second was an exploitive use of an unmanaged living resource that was soon depleted. The financial impact of the short-lived industry was marginal but probably positive, although the northern marine ecosystem was severely altered and probably rendered less productive thereafter. The third was an initially spectacular example of industrial regional development. Although some individual fortunes were made, many more were lost in the scramble for Yukon gold and the main lasting commercial development has been in the service sector. Subsequent developments have maintained an erratic cash flow within that region, but over any extended period the new wealth produced has not generated net profits or taxes equal to public investment.

In recent times, mineral and petroleum development have been the major industrial contributors to the economies of both Yukon and the Northwest Territories. These activities have provided a reasonably sound, if not very diverse, base for modest regional economies, but the net income generated within the region has remained less than the public outlay through government services, subsidies and welfare, and military expenditures. A great surge of private and public investment from 1968-1985 in preparation for commercial exploitation of petroleum resources, increased the cash flow to and from northern Canada dramatically. This not only altered the nature and intensity of government and industrial involvement in northern Canadian affairs, it changed the life-styles and socio-economic expectations of many northern peoples. A component of this surge of investment was increased scientific and technical knowledge, particularly in the sophisticated geosciences and the development of northern industrial technologies. These were accompanied by advances in knowledge of the natural environment and in the social sciences in order to ensure that large-scale industrial development would not cause unacceptable environmental or social changes. The anticipation of major economic benefits from petroleum and mineral resource development has been a major catalyst for the political development of the North and had a profound effect upon the scale, scope, priorities and institutional structure of research in northern Canada today (Chapter 3.1). However, the prospects of substantial net economic return from investments in petroleum development have greatly diminished in the short and medium term and perhaps evaporated altogether.

Those who are planning and evaluating science in northern Canada or anywhere in the polar regions must face the uncomfortable fact that, although we know much more about these regions and their actual or potential resources than ever before, the prospect that northern or polar areas will become self-sustaining in simple economic terms are not bright. There is always the possibility, even probability, that certain resources will be profitable in a local sense - another Prudhoe Bay or two, another Yellowknife, perhaps a platinum mine in Antarctica - but even these "winners" appear likely to bring with them demands for public investments and services that counterbalance or nullify their economic contribution to national wealth. Many agencies in the polar countries are carefully and sometimes desperately searching for any source of sustained economic benefit and employment in polar regions, such as the management and use of renewable resources, tourism and transportation and communications services. Although undoubtedly much more can be done in these fields than has been done in the past to develop profitable industries and small pockets of economic prosperity in northern regions, the hard fact is becoming apparent that none gives realistic promise of supporting the public expenses of northern regions in the light of present commodity prices, interest rates, geographical location of national or world markets, foreign political developments, and the changing populations, lifestyles, and the political and socio-economic demands of northern residents themselves.

Although there have always been those who pointed out that the "You come to get rich - damn good reason" phase of northern development, as Robert Service eloquently described it*, could only be ephemeral, the hope and anticipation of substantial economic returns from impending resource developments have been the dominant motivator of science and research in northern Canada. As that prospect diminishes, the motivation is being replaced by a desire to find alternative, diverse sources of income, and to look at the needs of northern regions and the obligations of the rest of the country in the absence of a significant generation of wealth in the North. There appears to be a slowly growing awareness of the need to judge northern priorities in relation to factors other than an increase in national wealth. This change in the standards against which we value and judge the importance of polar science and research will be a fundamental one.

---

* Service, Robert W., "The Spell of the Yukon". 1907, copyright Dodd, Mead and Company, New York.

3.4.4 Demographic changes

In northern Canada and in most arctic regions the local populations are expanding rapidly. Over the past twenty years, northern demographics have been affected by :

(i) a sharply rising birth rate of the Inuit (now the highest of any identified population group in Canada) and an only slightly less spectacular rise among northern Indians. High birth rates and an increase in the rate of survival to puberty have resulted in a rapidly expanding northern native population and a strongly skewed traditional age distribution. In some northern settlements, half the population is under fourteen years old.

(ii) an influx of adult non-native southerners, mostly between twenty and forty years old and with technical or administrative skills and interests, coming to northern industrial, government or defence centres. The attachment of these newcomers to the northern regions is often financial and temporary. They tend to desire and bring southern life styles, and their contact with indigenous populations and cultures is often superficial or minimal. In some parts of northern Canada recently arrived non-natives represent a significant segment of the population.

These changes followed an earlier period during which a dispersed and semi-nomadic northern aboriginal population moved into settlements - a change of life style whose pace and cultural implications were much greater than any rural to urban movements in southern Canada. The consequences of these changes on the economic, social, cultural and medical health of northerners have been profound, and constitute a powerful driving force behind all present-day human issues in the Canadian North.

3.4.5 Deterioration of habitats and general environmental quality

An important force driving modern research in the polar regions is the evidence of habitat sensitivity and environmental change. While there is not at present a demonstrated widespread crisis in arctic habitats, (although there are local problems), many lines of observation and study indicate convincingly that relatively small variations in physical, chemical and biological conditions have significant effects on the productivity of terrestrial, aquatic and marine habitats in polar regions. Low-energy polar ecosystems are tough and resilient, but at the same time tend to be very sensitive to slight changes in external conditions. For aboriginal peoples who depend on renewable resources (and who are now beginning to study the commercial potential of northern wildlife) and for the general long-term health of the environment, maintenance of the sensitive northern habitats is of the highest priority. Research and knowledge of habitat productivity and changes should be closely tied to environmental policies and resource management in polar regions.

Environmental and habitat changes in the arctic and antarctic regions may be from natural causes (the effects of recent changes in sea level in the Mackenzie delta region, or the variations in discontinuous permafrost are examples), or the result of human actions (accelerated erosion of soils over frozen ground; arctic haze; discharges of mine wastes into estuaries), but many of the most difficult and potentially most serious disturbances appear to result from a combination of natural and human influences in uncertain relations (climate change due to CO_2 warming, greatest in sub-polar latitudes; ozone depletion; effect of hunting or toxic substances on migration, habitat and inter-species relationships). Industrial activities in polar regions have a high potential for disturbing the environment compared with comparable enterprises in more temperate regions because of the sensitivity of environmental phenomena associated with freezing and thawing of water and the slow rates of chemical and biological processes at low temperatures. Because of the relative simplicity of high latitude ecosystems and the lack of a dynamic stability from many competing or counter-acting biological and physical influences, environmental disturbances of any kind may have dramatic consequences in polar regions and cumulative or synergistic effects become very important.

Environmental concerns in the polar regions are important not only for the well-being of those regions and the northern peoples, they are important in a global context as well. The polar regions act as sensitive indicators of regional and global environmental conditions. Oceanographic and atmospheric circulation systems move the products of industry to high latitudes where, because of the relative absence of local disturbances and the relative simplicity of the ecosystems, they can be detected and may have important consequences. DDT in penguin eggs in Antarctica and in arctic skua gulls are well-known examples of how biological systems can be used to monitor chemical distributions on a global basis. The Gulf Stream and North Atlantic Drift collect the accumulated, long-lasting, pollutants washed to the sea from industrialized eastern North America and western Europe and transport them to the Arctic Ocean, where their further chemical breakdown is inhibited by low temperatures and ice cover. "Arctic haze" is a manifestation of a similar process in the atmosphere.The Arctic Ocean basin is the ultimate depository for the unwanted persistent chemicals produced by much of the world's industry. Knowledge of the pollutants being delivered to the Arctic, and their fate, is an international responsibility.

Antarctica plays a special role as global environmental monitor. The "Clean Air Facility" at the South Pole, tens of thousands of kilometers from sources of industrial pollution, undertakes sophisticated detailed monitoring of the chemistry of air which has risen over the heated tropics and travelled at high altitudes to the southern polar regions. There it descends and gives a unique measure, not possible anywhere else on the planet, of basic atmospheric quality and the disturbing changes that are occurring in it. Data from the South Pole are important for proper interpretation of the international Arctic Aerosol Sampling Network (Alaska, northern Canada, Greenland, Iceland, Svalbard [Norway], Finland) that monitors the distribution, movement, chemical characteristics and environmental effects of industrial-source pollutants across high arctic latitudes.

The advanced air chemistry monitoring facility, recently established by the Atmospheric Environment Service at Alert, N.W.T., on the north coast of Ellesmere Island, will make somewhat complementary measurements of atmospheric quality far from direct sources of pollution, and is a major contribution by Canada to national and world environmental knowledge. This is an example of the essential unity of bi-polar science and the critical role that polar regions play in environmental issues important to non-polar areas. The value of these monitors lies importantly in their continuity; measurements must be taken consistently year after year, for decades, to provide significant information on the global condition and regional changes.

In the fields of renewable resource management and habitat protection, the Convention for Conservation of Antarctic Marine Living Resources (CCAMLR) of the Antarctic Treaty is the first serious international attempt to manage economically exploitable resources on an "ecosystem" rather than a "population" basis. The knowledge and experience from this convention is valuable to the protection and management of species like seals and whales in the Canadian Arctic, and has been applied to other fields of long-term resource management, such as the policies recommended by the Canada- U.S. International Joint Commission for the management of the aquatic habitats of the Great Lakes.

3.4.6 Political evolution and devolution

Another powerful driving force affecting the science and research in arctic regions in the next decade is the assumption by northerners of greater political authority and their emergence from the "colonial" status that has characterized northern Canada until recently. This complex process has constitutional, political, legal, economic and educational implications. It is being achieved through several complicated and lengthy processes such as the negotiation of comprehensive land claims, the devolution of legislative and administrative authority to territorial governments, constitutional negotiations with Canada's aboriginal peoples and proposals to divide the Northwest Territories. It has increased the influence of northern native communities in dealings with government and industry respecting the development and management of northern lands.

Somewhat similar issues have arisen and are being addressed in different ways in other circumpolar countries. The progress of political evolution in the circumpolar world, when considered in relation to the many common factors uniting circumpolar indigenous people and the influence of international circumpolar organizations such as the Inuit Circumpolar Conference and Indigenous Survival International, give these developments an international as well as a domestic dimension.

During our study, the Working Group was made very aware of the pervasive effect of political development on all aspects of policy, management, economics and inter-agency relations in northern Canada. We paid particular attention to the influence that emerging issues of self-government and devolution are having on the need for scientific knowledge and the conduct or support for research. Questions of renewable resources management, community planning, vulnerability to climatic change, technologies for pollution control, disease implications of changing diets and life styles, all have scientific aspects with political implications, and priorities that differ depending upon the degree of autonomy or authority of different groups, and upon which society or culture one belongs to.

3.4.7 Influence of Public Interest Groups

An interesting characteristic of developments in arctic Canada is the extent to which the determination of scientific priorities and many research activities are influenced by non-resident public interest groups. "The North" and its history, wildlife and cultures have a powerful hold on the consciousness and concerns of groups of people resident in southern Canada and other countries, who are prepared to take political or public action on behalf of the North. The reasons behind these concerns and actions are many, including a feeling that the few inhabitants of the North are relatively powerless to speak for their large land, and vulnerable to exploitation, a feeling that short-sighted policies will or have caused environmental and cultural damage in the rest of the country, that the North provides a last opportunity "to do it right", and concern for the fate of northern wildlife.

Whatever the reasons, non-northern Canadian and international public interest groups are responsible for much of the popular and political interest in the North and in polar issues today. They influence the issues and public priorities in ways that purely political or economic factors could not do. They also have an important influence on the perceptions that northerners have about the concerns and political activities of southerners. These in turn have a very real effect on the priorities for allocation of funds for northern research, and on the selection of northern subjects for study at universities. To a degree that is not found in any other part of the country, science and scientific knowledge of the Canadian Arctic is influenced by nonresident groups who have a basically intellectual or emotional, rather than an economic or political stake in the outcome.

4. SOME MAJOR PROBLEMS - AND OPPORTUNITIES FOR ACTION

The submissions received by the Working Group articulated many opinions, suggestions and opportunities for dealing with the challenges noted in the preceding section. The Working Group has sorted these into four main categories.

4.1 Public and Political Interest

At a symposium of the Royal Society of Canada on "Science in the Canadian Arctic" in 1982, one of the members of the Working Group stated:

> "Canada is an arctic nation. Two-thirds of our country is subjected to a climatic environment which is 'arctic' in any commonly accepted sense of the word. The nearby presence of arctic conditions, and the closeness in time to our own day of the explorers and pioneer settlers, have given modern Canada, as a nation, a character which is distinct from that of our main European parent countries or our neighbours to the south. Nevertheless, most Canadians, and Canadian politicians, are concerned mainly with the southern fringe of our country, where most of us live; and we try to make Canada, and Canadian life styles, as non-arctic as we can. Despite the efforts of the Science Council and visionaries like Louis-Edmond Hamelin to have us look North, and despite the excitement and expense of industrial forays into the high latitudes to develop resources in recent years, as a people we are essentially and determinedly southward-looking or eastward-looking. Thus, during the past few days, lectures and symposia have looked at the development of ideas and scholarship in Canada during the last 100 years mainly in the context of growth of knowledge in the mid-latitude European world and the United States. Only incidentally has there been attention to what

> the knowledge and understanding of and within arctic regions has meant to the conceptual and intellectual, as well as the economic and political, development of Canada.
>
> Most Canadians tend to think of the northern two-thirds of our country as a frontier region, a region into which we bring the skills and knowledge of our science and technology which has been developed in more southerly regions. We don't commonly think of the Arctic as a region that has led our thoughts and shaped the rest of the country in our actions and expectations, or as a place where scientific activities have results which extend beyond the Arctic and have national or world-wide importance. And yet, to a degree greater than is often realized, arctic science has contributed vitally to world science, and knowledge and concepts about the Canadian Arctic have had a strong influence on the history of North America and on world scientific thought."*

And after travelling across Canada in 1983 to study the needs and priorities for northern research in Canadian universities, the Executive Director of the Association of Canadian Universities for Northern Studies reported, with regret :

> "My strongest impression, so far, is that we cannot take for granted that there is a widespread acceptance in this country of the **need for** northern scholarship, nor is there ready or general acceptance of the **needs of** northern scholarship and the requirement for its continued funding and general support. These remarks will hardly come as a surprise to members of the university community who have been engaged in northern research and training over the years. They are indicative of the long standing situation in Canada that the North is not central to our national psyche. It is not so much a frontier in our consciousness as a periphery.

---

* Royal Society of Canada, Transactions, Series IV, Vol. XX, 1982, p. 373

But there are factors in the 1980's which may tend to exaggerate this long standing perception and produce not just a hiatus but a new slump toward absent-mindedness about the North.

The first is the obvious lull in northern activity, - a marked contrast to the interest of the past decade. This factor makes our case for sustained research and training all the harder to argue.

The second, and a crucial factor to be reckoned with in our community, is that there is no longer any automatic recognition of how "science" and research can serve northern needs and problems and how it can be especially relevant to people living and working in the North.

The third is that, as interest in the North has shrunk, so too we will be faced with shrinking budgets in all sectors, for northern scholarship.

The fourth is that I believe we may experience new difficulties in attracting and involving the next generation of students, both from the North and south, into northern scholarship.

The fifth is that in some universities in Canada, the commitment to northern work is being seriously questioned as a proper subject for funding and support, especially in times of diminishing government funding.

To sum up, I must say that our northern regions seem no longer to be important items in our national agenda. The slow gathering of momentum in interest and commitment in this country to northern affairs and issues over the past forty years now appears to be subsiding..."*

---

* Association of Canadian Universities for Northern Studies. Annual Report, 1983.

The Working Group had to consider whether the uneven attention given to northern science and research over the years reflects a natural order of national priorities in which the northern half of the country is simply not very important in comparison with the more populated parts of the country. We found that while the northern and polar science community is convinced that Canada has vital national economic, social, cultural, environmental, political and security interests and challenges in the Arctic and in the polar regions, the political and public interest in these concerns of the science community and its ability to help find workable solutions to northern problems remains very limited.

This situation is not new. The Canadian Parliament was reluctant to support the International Polar Year in 1882-83, despite the fact that government scientists had taken part in the planning, and five expeditions were to be based in arctic Canada. Government support of the first significant Canadian northern explorations, the scientific research and "possession of the land" by Bernier (1902-1911) and Stefansson (1913-1918), was strongly criticized in the House of Commons as a waste of public money and politicians' time. The Second International Polar Year in 1931-32 fared little better in garnering public support; and its very considerable scientific achievements in the name of Canada were made by dedicated and enthusiastic senior scientists on shoestring expeditions who served essentially as volunteers and who received almost no material support or popular recognition.

The failure of most Canadians to incorporate arctic awareness into day-to-day perceptions means that public awareness of northern issues rises and subsides according to the news of the moment. It does not develop a momentum that leads to collective knowledge or a national resolve in terms of government policy. Northern issues are dealt with in our educational system in a trivial manner, if at all. The participation of Canadian universities in northern or polar studies has usually depended on the enthusiasm of one or two professors and in no single case on full institutional commitment. Nevertheless, from time to time, Canada becomes a world leader in some areas of polar science and technology develoment. Where this has happened, as in auroral studies in the 1930's or advanced methods of topographic surveying in the 1960's, the public has been unaware or unconcerned, and our scientific successes have not helped to develop national northern consciousness.

It was in light of this background of spasmodic, disconnected episodes of concern and expertise, and a general low level of public interest or political commitment interspersed with short bursts of enthusiam, that many of those we consulted felt that a greater public awareness and understanding of the national importance of arctic and polar issues is a vital Canadian need. They believe it will be needed if Canadian knowledge of its North, and of the polar regions, is to develop in a balanced and comprehensive fashion, and be the basis for intelligent actions and policies and for sound economic and social development. There are also many who feel that the promotion of northern and polar science, making evident its relevance to national and northern needs, will require an identified organization - a new or a revitalized polar institute in Canada -, whose main role should be communications and public awareness.

4.2 The Perspectives of Northerners

Different perspectives on northern science and research issues are held by northerners and most groups in southern Canada. Typically, the approaches used to express concerns and take action on them are also apt to be quite different. Recognising the dangers of making general statements about northern society, the Working Group nonetheless feel obliged to point out, to southern readers, that there is more variation and range in individual opinions and concerns about northern science among the smaller and varied northern groups than there is within the larger, more homogenized, southern Canadian society. This is important because any major change in the organization and support of science in northern Canada will inevitably be the result of decisions made within the system dominated by southern values and perspectives, yet those most affected by such changes will be northerners.

Both native and non-native northerners are aware that science and the technology bred from research are important to modern social, economic and institutional life. Despite a suspicion about the value of modern science and scientific research apparent in the North there is also a parallel respect for past traditions and an appreciation of both old and new skills, know-how, and better techniques. The uncompromising northern environment and the need for skills to make a living, either using traditional resources or at jobs that serve southern Canada, have led to a desire to learn more in order to do things better, and a general acceptance of change to a degree that is not as evident in southern communities. Many of the social and technological changes most significant in northern communities are not efforts to emulate southern communities or life-styles, but to develop something different and distinctively northern.

The acceptance by both native and non-native northerners of science and research as a part of their life is often accompanied by the realization that scientific activity can be either beneficial or detrimental to the development of northern society. Major concerns emphasize the need to determine the purpose and achieve control of the research and the application of results.

It became clear to the Working Group that the people in the Canadian North who are concerned about the future of science and research in the North fall into three main categories:

(i) Territorial government bodies and formal organized research institutes such as the Science Institute of the Northwest Territories and the emerging Yukon Science Institute. These groups represent a "formal" scientific movement in the North, and play an important and expanding role in developing a general scientific consciousness among northerners. They also serve to create links with scientists in the rest of Canada. An important role for these groups is to transfer some of the findings and methods of national and circumpolar science into the specific research needs of northern governments and communities.

(ii) The research interests and organized research capacities of northern native organizations. Examples are the Council of Yukon Indians and the Makivik Research Department in Nouveau-Québec. These groups organize science programmes that relate directly to needs identified by native northerners. They are involved with the development of research skills among natives and with the establishment of local scientific activity on topics that are important to native northerners. The concern with science and research within the native organizations is at least in part related to the transfer, over time, of research capacity from non-native scientists working for native groups to native scientists. This transfer must take place in stages; and is far from complete. The final result should be a co-ordinated approach to research, not a division into "science for southerners" and "science for northerners." In part the concern is also with the nurturing and transfer of "traditional science".

(iii) The third important group is comprised of universities, government agencies or industrial groups (including consultants) that maintain a continuing scientific presence in the North. These groups are responsible for much of the current scientific knowledge of the North and for the integration of their material with the scientific research from other parts of Canada and the world.

The Working Group heard much about the relationship or distinctions between the scientific methodology and data base of native peoples and the approach of discipline-oriented researchers who follow European or American scientific traditions. "Traditional knowledge" is a term some native groups use to distinguish their own information base and scientific interests from the methodologies and data bases of non-native researchers. That there are bodies of reliable knowledge and experiental understanding about many aspects of the North, inaccessible or meaningless to the southern scientific world unless it learns the value terms of elements of native northern societies, cannot be doubted. It is important for all Canadian scientists to recognize the importance of this type of knowledge and information without creating unnecessary distinctions about its significance and value. It is important to capture the data content of traditional knowledge in a systematic way that will build a bridge between traditional native and non-native approaches to science. The interpretation and application of traditional knowledge can serve as an entry point for native northerners into formal research. At the same time, serious interest by southern-trained scientists in the information and knowledge bases of northerners can expand the potential for conventional science.

A concern of both native and non-native residents of the North is that they view themselves at present as little more than casual participants in scientific activities controlled from southern Canada. Many northern groups have taken the position that control over research must be shifted from government and industry in southern Canada to resident groups in the North. Proposals for accomplishing this, however, can vary substantially between non-native and native northern residents. Furthermore, it is different in northern Québec, the Eastern Arctic, the Western Arctic, the Delta, and in Yukon. A successful northern science institutional structure would have to be able to accommodate these differences.

Some groups are quite specific about what they mean by **control** of northern science. They want adequate funds to conduct research, the freedom to set research priorities, research facilities and information systems situated in the North, and management over or access to resident professional scientists. The stated objective is not to move all science north but rather to have a fair distribution of scientific activities, funding and priorities between northern and southern interests.

Many northerners believe two kinds of benefits will accrue from increased control over northern science:

(i) **economic,** either directly through employment in positions that have some influence in the political and social development of the North, or indirectly through local expenditures on research, provision of services, the application of research findings to the local economy, and, in the longer term, through economic development in the hands of northerners;

(ii) **social and educational,** coming from the knowledge that the resident society has a real influence on the knowledge obtained and the decisions that are being made in the North; from having a greater body of relevant and understandable information about the northern environment, its resources, institutions and cultures; a closer tie between local concerns and formal education and contacts on an equality basis with other groups and cultures; from knowing that one is, to a greater degree, "master in one's own house".

If a northern science system is to be effective, it must be able to work with, recognize and support these concerns and perspectives.

4.3 The State of Northern Science

It is widely acknowledged that Canada's scientific and technological performance in recent years has lagged behind that of most industrialized countries. Remedying this situation is the focus of the activities and policies of the Ministry of State for Science and Technology and a number of thoughtful programmes of other federal and provincial agencies, universities and industrial associations.

The general deterioration of Canadian science is particularly serious with regard to polar science and technology, for it is in the North that general social and economic development and Canada's place in the community of nations depend most directly on scientific knowledge. The need to develop awareness and understanding of the characteristics and responses of distinctive cultures and environments, and for activities to develop technologies of transportation, communication, resource development and defence in our northern regions is considerably greater than it is in more temperate latitudes, where such knowledge is already much greater, familiar, shared with other countries, and a part of everyday life. In the polar regions, Canada cannot depend confidently on the science and technology of other countries to meet her needs.

There are many areas where Canadians have achieved excellence in northern studies and polar sciences. In specific areas of natural sciences, and in many disciplines in the social and medical sciences we have achieved international recognition. But there are other areas where we have no sustained research programs and little domestic expertise, and we must depend upon the investigations of other countries for our basic knowledge. Although the Working Group did not attempt a technical appraisal of the state of Canadian northern science, some general conclusions are apparent :

A) Canadian science in the North is in some cases of less than highest quality;

Many years of constrained budgets and a mission-oriented or results-oriented support of northern science, with no corresponding investment of resources in the encouragement of creative work in selected areas, have resulted in an overall pattern of often mediocre or run-of-the-mill northern science in Canada. To a distressing extent, research managers in government are more accountable for the "dollar output" of northern research than they are for research that is done in other parts of the country, mainly because of the proportionately higher costs of northern studies and the fact that a high proportion of northern research is funded by policy-related agencies or for industrial purposes. This situation discourages the scientific risk-taking that is essential to creativity. For many of the same reasons, university researchers are inclined or constrained to undertake studies in the North which tend to be scientifically safe and predictable and thus are less likely to be truly imaginative and intellectually daring. The result is that science in northern Canada today tends not to be very productive of new scientific ideas or intellectual breakthroughs.

Canada science in the North also tends to be old-fashioned. New techniques and new scientific theories spread slowly through Canadian northern research, mainly for economic and institutional reasons. This situation is not helped by a funding situation that discourages or even prevents the entry of bright young scientists into the world of arctic research. A great deal of Canadian northern or polar research is not published in peer-reviewed scientific journals but appears in agency reports or conference proceedings. Thus the major mechanism for scientific quality control, the critical review by one's peers, is bypassed. Because the total volume of arctic research is small, the review system for arctic research is poorly developed. Many scientists investigating Canadian northern or polar problems can work for years without having the calibre of their work critically tested by their scientific colleagues. Research undertaken in response to native concerns appears, in particular, to be rarely subject to critical scientific examination.

B. Most centres of northern study are too small to be fully effective or sustain world-class research;

In areas where Canadian polar science is vigorous and in touch with leading science in other countries, the activity depends upon one or two individuals and the calibre or momentum is vulnerable to disruption or collapse if those key people retire or move on. Although this is true of many institutions and disciplines, it is more critical with respect to northern science, as no Canadian university includes a commitment to polar research as part of its corporate culture. Among Canadian government agencies, universities or industrial interests, only in the Department of Energy Mines and Resources is there anything like a "critical mass" of interacting, professional, front-rank productive scientists with northern or polar expertise. In several other countries, to whom northern or polar matters are of less national importance than they are to Canada, there are some vigorous interacting cells of northern scientists. A perusal of the citations in major international bibliographies in any scientific discipline under headings such as "arctic", "northern regions" or "polar" will show a high number of entries from these countries, and a disproportionately low number from Canada.

C. Science in northern Canada is becoming schizophrenic

Northern science is expected at one and the same time to advance knowledge and understanding and to be useful to, and responsive to, the needs and values of northerners and the demands of industry for the knowledge base from which to develop new technologies. Were there an adequate total scientific effort in the Arctic, that spanned from theoretical investigation to experimental inquiry to industrial R&D, (as is at present the case in many fields, including polar research, in Germany and Japan), these different demands would be a stimulus and a means of giving coherence and purpose to the whole science programme. But in the severely constrained and thinly-stretched communities of northern science in Canada, these varying demands are disruptive and shattering to the productivity of research programmes and to the morale of scientists.

The Working Group encountered many examples of the difficulty, frustration, and even despair caused by the attempt to carry out state-of-the-art research programmes and at the same time and with the same resources, contribute to the solution of urgent northern problems. The crash programmes of the big-spending 1970's led to expectations of "expertise on demand". Zoologists just starting a carefully planned study of caribou ecology are diverted to testify on an environmental assessment panel and expected to make a definitive statement about the harvestable capacity of a hunting area before the data are gathered. Those studying breeding habits of whales find that, unbeknownst to them, they have become our national experts on the effects of noise on marine mammals. Engineers versed in construction design for permafrost areas are assumed to have knowledge of climate change, and so on. One predictable result of this imposed schizophrenia is that many leading scientists have become disillusioned with trying to do good science in the Canadian North, and have turned to other fields. There are even little bands of productive Canadian polar scientists who have become scientific expatriates, continuing their polar interests and studies in northern Canada through programs funded by other countries and based in foreign institutions. Among the submissions we received were a number of pessimistic ones from senior Canadian scientists, heads of university departments for example, who once had been enthusiastic northern researchers but who have given up northern work because they encountered continued disruption and little support, and who, we suspect, are advising their students not to enter polar science unless the situation is changed.

D. Spasmodic development of northern technology

Canada is a leader in many polar technologies. For example, we are in a commanding competitive position internationally in support equipment for polar field operation. Convincing evidence of this is the widespread use of Canadian vehicles, housing, clothing, and support machinery in Antartica by virtually every nation carrying out activities there, and the extensive use of Canadian equipment in Soviet resource development activities in northern Siberia. But the application of Canadian science to the development of this successful technology has been mixed.

Canadian scientific studies have been important in some areas, such as ionospheric research leading to northern communications and advanced navigation methods, geotechnical studies of permafrost as a basis for foundations design and pipeline construction, and coldwater oceanographic research leading to sub-ice oilwell technologies. In some other areas some of our most successful northern or polar technologies have developed without any substantial input from the northern sciences; vehicles for snow and muskeg, and transportable northern housing are two examples. In still others, successful Canadian polar technology has been dependent on science and research done in other countries; such as research to provide basic information on sea ice characteristics essential to design of Canadian icebreakers or offshore production platforms, or the development of special steels and welding techniques for cold-weather operations (although C-FER hopes to change this).

Too often the development of Canadian polar technologies has been piecemeal, responsive to a market which usually depended upon government stimulation (such as PIP grants) and directed exclusively to a specific short-term use. When the immediate purpose has been met or the stimulation is removed, the development in that area of technology has ceased, and the expertise has dispersed. A recent dramatic example has been the rapid dismantling of polar technology research teams and facilities in Calgary within months of the decline of oil prices. Only in areas where Canadian winter technology, with its broader market, could be easily adapted to northern and polar needs, such as with STOL aircraft, over-snow vehicles, and prefabricated northern-style housing, have Canadian firms been able to retain the momentum and expertise to be adaptable to new demands without starting all over again.

The situation with respect to polar technology development in Canada is different from that in, say, aeronautical research, building construction, or mineral technology, where centrally funded technology development laboratories pursue new basic technologies and areas of expertise, to a considerable degree sheltered from immediate market fluctuations in order to be able to assist Canadian industry to take advantage of new opportunities when they arise. Although it is not within our mandate, the Working Group feels that there is merit in considering the need for an institution dedicated to the development of appropriate polar technologies.

E. There are serious gaps in the scope and range of Canadian northern science

Most polar research in Canada is in the natural and applied sciences, although there has been a modest increase in the human sciences, such as archaeology, anthropology, ethnology, history, cultural adaptation, and the biomedical disciplines. Serious research in fields not normally considered "science", such as law, economics and the study of policy development and political interaction has been minimal in comparison. In a few of these areas individual professors or small academic groups have made efforts to establish significant research programmes, but they have encountered great difficulties, due largely to an assumption, deeply ingrained in Canada, that these areas are not "science" and therefore their study will not lead to useful new knowledge.

In Canada, few schools of law, economics or political science have arctic experts on their faculties, although a few scholars in Canada have made outstanding contributions. International journals in these subjects contain few articles by Canadian scholars and Canadian scholarly journals rarely carry papers on northern or polar issues. The scope for peer review within Canada or scholarly study of northern issues is very limited. Particularly worrisome is the paucity in Canada of modern background research or comparative research into the legal, economic and institutional aspects of rapidly evolving native issues in the North and the ramifications of international quasi-political organizations that are likely to become important factors in Canadian northern politics in the future.

In other arctic countries, university departments of humanities, political science, or law include professors specializing in polar affairs; in Germany and in France there are chairs of polar political science. The Nansen Foundation in Norway (sometimes popularly called the "Institute for Polar Politics"), the Scott Polar Research Institute of the United Kingdom, the Institute for International Law in Germany, and the Center for Strategic and International Studies in the U.S.A. are examples of independent non-government institutions that have made a specialty of the scholarly study of polar issues. These institutions give their respective countries a richer knowledge base from which to manage their polar interests and affairs.

4.4 Problems in the Pursuit of Northern Science

4.4.1 Fragmentation and isolation

Among the submissions we received from those engaged in northern research, whether in government, universities or private associations, a very common complaint was the lack of contact, information and "coordination" within the northern science community itself. As mundane as these words are, the Working Group is convinced that these complaints reflect a serious and debilitating problem for Canada. Put simply, although on a national basis there is not an excessively large number of people engaged in polar research, many of those who are active in this area seem not to know what others in the field are doing.

Perhaps as important as lack of contact with those that should be co-workers, many of those engaged in northern science are equally remote from the evolving political, economic, and social context in which they work, and they are unwilling or unable to relate their studies to the research needs of government, industry and northern society. Conversely, senior decision-makers in government and in the North, and the northern population as a whole, often seem to have little knowledge of what research is being done in the North and how its results could be made to serve their needs. These problems are not, of course, unique to the North; but there is ample evidence that they are perhaps less tractable than the problems of improving interaction among scientists or between scientists and their "clients".

There are many factors that contribute to this isolation which is felt so acutely by much of the northern research community. Some, such as the great geographic distances and physical problems of communication, the relatively large number of small institutions, and the fact that northern research ranges in scope and complexity across the full spectrum of physical and social sciences, (the small northern science community is studying half the country, after all), are simple facts of the Canadian scene. Other factors, however, include the lack of an efficient system of communication among northern researchers, and among the researchers, those whom they serve, and those who fund them. Still other causes relate to a lack of discipline within the research community and a still immature and sub-critical state of northern science. Research in the Arctic, in many disciplines, is sufficiently distinctive in its metholodogy and goals that it does not integrate easily with other research in the same discipline; yet beyond the primitive and exploratory stage of descriptive knowledge there is no real validity to "arctic science" as a discipline in itself. Arctic researchers find themselves often to be anomalies on the national and world science scene.

Paradoxically, scientists working in the Antarctic clearly experience much less of feeling of scientific isolation. This is because Antarctic research is not focussed on current national socio-economic or political priorities, is often the polar component of leading world research in several disciplines, and because of the vigorous international scientific exchange and sharing promoted by the Antarctic Treaty and the Scientific Committee for Antarctic Research (SCAR). Antarctic scientists are in close contact with general global developments in their respective scientific disciplines and with each other. This paradox is one reason there have been repeated proposals for creation of an international arctic science body similar to SCAR.

There appear to be instances where this lack of communication among Canadian arctic scientists leads to simple wastage. There is probably not much duplication of research, but different people may start from the beginning on obvious problems without knowing what else has been done, and good research results, that could be useful for others to build on, may lie un-used until out-dated. Given the declining funds available for northern research, this is a serious problem. Canada can ill afford to waste research dollars of any kind.

An equally serious consequence, however, is the absence of general awareness of what research is **not** being done or what expertise the country is losing through lack of adequate support or follow-through to take advantage of what has been learned or the skills developed. Also, the lack of contact and shared information among the research community undoubtedly affects the quality of what research is being done. World-class science to-day requires an on-going dynamic of critical awareness, interaction, and self-review among scholars and disciplines, just as much as it needs solid, sustained financial and administrative support.

While there are a large number of institutions engaged in northern research in Canada, most of these, whether public or private, are quite small in size. There are advantages to this situation in terms of the independence and efficiency of the individual scientists and the flexibility of research programmes, but it often means that the researchers or the programmes lack the level of institutional support that would give them ready access to libraries, information systems, fund-raising assistance, and the state-of-the-art technology needed in modern high-calibre science.

A number of activities are devoted to communication and dissemination of information among scientists and researchers on northern Canada or polar studies. The Association of Canadian Universities for Northern Studies, the Northern Science Network of the Man and the Biosphere Program, the Northern and Offshore Information Resources Group and the Arctic Institute of North America have been conspicuous in this respect on a national basis, as have been the Arctic Petroleum Operators' Association and some commercial publications related to northern resource development in fields of industrial research. The Arctic Institute of North America is building a comprehensive and readily available arctic science and technology information system, and the Northern Libraries Colloquy has done much to integrate basic scientific reference material on the Arctic. Despite these activities, it is clear that isolation from knowledge of other on-going work, and from national and international developments related to the North and the polar regions, remains a chronic and pressing problem in Canada.

The members of the research community themselves must bear some responsibility for this pervasive sense of isolation. The Working Group has noted with concern the tendency of some senior figures in the field of northern research to see lack of information and contact as a problem to be solved by someone else; that somehow they should be provided with a regular flow of digested information about what is going on in the rest of the world. It appears that polar scholars and scientists in some other countries operate under professional standards that demand a greater individual responsibility for communication and awareness outside their own subjects than do their counterparts in Canada. The situation is not unrelated to the relative lack of criticism and peer-reviewed publication of the results of polar science in Canada.

4.4.2 Identification of the northern dimension

The Working Group found a great deal of dissatisfaction and downright resentment respecting polar research among northerners, northern aboriginal organizations and northern territorial governments. By and large these groups view scientific research in the North as an activity conducted by a southern "establishment" that orders its affairs with little sense of accountability to northerners, little sense of responsibility to address the research needs of northerners, and little regard for the capacity of northern aboriginal peoples to contribute to, and participate in, polar science and research.

Despite the recent emergence of a few research institutions in the North, (Section 4.2), most polar research by Canadians is conducted and directed by federal government departments, universities and corporations based in southern Canada. A small but significant amount of northern research is also carried out through provincial governments. As we have already pointed out, these do not constitute a centralized monolith; but, from a northern perspective, they share a remoteness and independence from the concerns and dynamics of northern society that makes it difficult for northerners to associate their welfare with them. In many cases, scientists and researchers have been viewed by northern aboriginal peoples as representatives of forces for imposed change, about which they felt ambivalent or even hostile, such as industrialization and centralized wildlife management.

There are two distinct components to the unease felt by many northerners about science and research in the North. The first is the wish of northern governments and communities to acquire greater control over public and private decision-making as it pertains to Canada's northern regions. This sentiment is part of the general, complex political development that northern Canada has been undergoing for some years and is not peculiar to the world of science and research.

The second component relates to the involvement of northerners in the actual planning and conduct of polar research in Canada. Many northerners, especially aboriginal peoples, express dismay at the importance given by scientists and funding agencies to what they perceive as obscure or secondary research fields, while badly needed research relating to their most basic concerns, such as the long-term medical effects of radiation or the productivity of northern inland waters, remains undone. They seek a greater influence over the determination of Canada's "national" research needs in the North and an increase in the collective sense of accountability of the northern research community to some urgent and fundamental northern science needs that are not perceived in southern Canada as scientific or political priorities.

For years, it has been commonplace for northern communities to express resentment at the tendency of many scientists and researchers to work in northern areas without informing the residents of the nature of their work, or inviting their participation and sharing the results with them. They are perceived as "taking" from the North without "giving back" anything to the North in return. A serious variation of this complaint is the inability of young northern science students to benefit from the activities of scientists in the North. At the recent annual meeting of the Association of Canadian Universities for Northern Studies, the President of Arctic College in Fort Smith complained that his students could look out the window and see polar scientists coming and going, but had to rely upon the Encyclopaedia Britannica to learn about their own region! Makivik Corporation, which invests heavily in scientific research in northern Québec, reports considerable difficulty in making national and international contacts to assist their work and to help them train young Inuit researchers.

Northern aboriginal peoples are understandably sensitive to the inability or unwillingness of many polar scientists and researchers to incorporate indigenous knowledge of northern phenomena in their work, especially when that work leads to important policy decisions such as harvesting quotas or the level of acceptable environmental risks for industrial development. The "melding" of traditional or indigenous knowledge with western scientific methods of observation and analysis is an extremely complicated issue. There are no easy or short-term solutions, but progress is being made (Section 4.2), and mutual credibility is being established in some areas of environmental and wildlife knowledge. At the same time, there is a real fear by indigenous people that if they freely provide their traditional knowledge to "modern" researchers, such knowledge will be used by policy-makers to destroy the indigenous values and way of life. Unfortunately, there are a few incidents in the history of northern Canada and other polar countries that lend justification to this fear. The continuing persistence of this problem contributes significantly to the alienation of the polar research community from the peoples of the polar regions.

It is not possible for us to make specific prescriptive comments on how or to what degree Canada's collective efforts in polar science and research should be re-directed to respond directly to these concerns of northern residents and their representative institutions. Even though improvements are currently taking place, and even though the answers to many northern concerns lie in general political and educational reform rather than new science policies and institutions, we believe these are serious, legitimate problems that should be given much greater weight by the research community than appears to be the case currently. These concerns and problems are genuinely circumpolar, and have been eloquently expressed by the Inuit Circumpolar Conference in statements of principles, manifestos, and policy proposals. The identification of a genuine northern dimension should be one of the cornerstones of federal policy for polar science, and an important component of DIAND's specific mandate for research in the North. It must be a central feature of any comprehensive institutional changes made to foster polar research in Canada.

We believe that the proposition that the Canadian polar research community should contribute to the resolution of the social, economic, educational and environmental challenges facing northerners is axiomatic. In fact, our collective national effort, whether expressed through research institutes or otherwise, should be distinguished from those of other nations engaged in polar research by its on-going accountability to northern Canadian public concern and opinion. If such a commitment is not made, then polar science and research will continue to suffer from political controversy in the North and to be associated with outside forces that northerners feel should be contained and checked, rather than becoming involved with and supporting. The on-going assumption of greater legal and de facto decision-making authority by northern territorial governments and aboriginal land claimants must be acknowledged and respected by the polar research community.

Despite the common preoccupation of most scientists with their own sophisticated spheres of investigation and their tendency to ignore local issues and priorities, there are welcome exceptions. We applaud the efforts and successful accomplishments of some researchers who not only respond to the concerns of northerners in the course of their work, but who have been active and constructive in developing among northerners a genuine interest in science, in their own history, and in the study of northern phenomena. These successful examples make it clear that involvement by northerners in modern science does not necessitate an abandoning of northern values, and that making modern science significant to northern people does not mean a lowering of scientific standards.

The isolation of northerners, both native and non-native, from the mainstream of northern science and research has, in some cases, led to an overly insular and short-term view of science. It may be responsible for the growth among many northerners and some policy-makers of unreasonable expectations about the ability of science and research to solve extremely complex socio-economic and political problems. Unrealistic expectations of what particular scientific activities ought to do soon leads to disillusionment with science in general. The ability of northerners to harness science and research to their benefit will depend as much on their own involvement in higher education and training as on legislative power or administrative control. Northern opinion leaders must complement their immediate concerns for authority and funds with a longer-term perspective on the value of polar research to the North, and develop a realization that adequate understanding of their own regions can only be obtained if local knowledge is related to the rest of the world.

Concerning the role of northerners and northern agencies in Canada's national polar research effort, the Working Group makes the following observations :

1. The polar research community must acknowledge that while the world of polar science and research should have its main focus on knowledge, it cannot and should not be divorced from the fundamental political debate among northerners as to their long-term political, economic and social future. For its own sake and to ensure continuity of support and the relevance of its research, the polar research community must invest more effort in developing working relationships with territorial governments and national and international aboriginal organizations. This is true for all branches of science, not only the social and applied sciences.

2. New territorial government science centres, such as the Science Institute of the Northwest Territories, and the research activities of aboriginal organizations like Makivik Corporation and the Council of Yukon Indians are among the most important and encouraging recent developments in the field of polar research. In the absence of a fully-fledged system of higher education in the North, it is these institutions that offer the greatest potential for the in-depth, significant participation of the northern community in polar science and research. The support of these and similar institutions should be a priority for governments, industry, and the university community. However, as all these institutions are still evolving, care must be taken that support from established southern sources does not force a premature rigidity and hampering of creativity or experimentation in the name of accountability.

3. We doubt that creation of a new national research institute would be the best way to address the problems of scientific training and education in the North or the incorporation of indigenous knowledge into polar research in Canada. These important problems must be solved in the North by northerners

themselves, and by industries and others active in the North, through and within the full range of scientific and educational institutions and agencies concerned with northern research. They should not be relegated to the responsibility of a separate agency. However, any new institutions formed should incorporate a dimension of involvement by northerners and an ability to give priority to northern concerns.

4. There is a need to draw the present northern scientific institutions into the mainstream of polar research in Canada by improving communication among them, and between them and other polar research bodies. In this regard, we note the current efforts of the Inuit Circumpolar Conference to develop a comprehensive arctic science policy and urge the polar research community to offer its support and assistance for this endeavour. We also note the systematic and thorough efforts of United States federal government agencies and university funding agencies to develop openly, with a public review that has included special workshops in native communities, a five-year plan for arctic research. Canada can profit from these developments.

4.4.3 Canada and international relations in the polar regions

There is a slowly growing awareness in Canada, and within the Canadian government, of the present and potential importance of the activities of other arctic and non-arctic nations in the polar regions, and of the efforts of Canada's northern aboriginal peoples to forge links with their counterparts in other polar nations. This whole subject is referred to generally as the "circumpolar question", and its emerging importance is reflected in the forceful call for a northern dimension to Canada's foreign policy in the recently released report, Internationalism and Interdependence. The Government's response, "Canada's

International Relations" (Dec. 1986) to this report contains firm statements recognizing the "northern dimension of Canadian foreign policy".

For Canada, the circumpolar dynamic is made up of a complex mix of opportunities for co-operation, competitive challenges, and potentials for conflict. For scholars, northerners and federal departments like DIAND, the realization that other people and other nations are facing political, economic, environmental and cultural problems similar to those in northern Canada has kindled an interest in learning as much as possible from their experiences. For those concerned with policy, economic development and sovereignty, the recent increase in the polar research activities of countries such as Norway, Germany, Sweden, Japan, U.K., France and the U.S. is giving concern that these countries will eventually erode Canada's competitive position in polar science and technology and strengthen their voice in polar political affairs. Failure to pay adequate attention to security and sovereignty challenges can jeopardize vital national interests. The continued activity of the Soviet Union in polar research, and its increasing, though still limited, willingness to share research results and co-operate in northern science, (as shown for example in the erratic but generally positive results of the renewed Canada/USSR agreement on Co-operation on Science in the Arctic and the North), adds another complex dimension to this mixture.

Responding to a general international recognition that the importance of the polar regions is increasing, and that scientific research is fundamental to any modern polar activities, several nations have taken policy steps to increase their involvement and influence in high latitude science. In 1984 the United States Congress enacted the Arctic Research and Policy Act. Under this Act, the President appointed an Arctic Research Commission and an Interagency Arctic Research Policy Committee and instituted a comprehensive assessment of American polar research. Within the last ten years, Germany has established a new polar institute, built a large modern icebreaking research ship, and now invests millions of dollars annually in polar research. Sweden, Japan and Norway have each reorganized their polar science structures and increased their sustained financial commitments to both arctic and antarctic science. Denmark is creating a new institute for bi-polar studies, and also supports science institutes in Greenland which are under local management. The United Kingdom has reinvigorated its long-standing polar research interests and reorganized the structures for government support of science in antarctic and arctic regions.

A good indicator of the growing importance of polar research to some of these countries is that they have designed new polar research institutions that report to high-level political authorities. The United States Arctic Research Commission reports directly to the President, the Swedish Polar Research Secretariat to the Swedish Parliament, and the Alfred Wegener Institute of Germany to the Minister of Science. This high level of accountability reinforces the ability of these nations to assess and manage polar research as a discrete subject rather than simply as components of the activities of numerous public and private scientific organizations.

These developments should be viewed in a positive light. All these countries are open to co-operating with the Canadian polar research community, and many of their activities can be associated with Canadian research, to the benefit of all. Canada stands to gain in many ways from an increase in the general level of knowledge about the Arctic and the Antarctic **if it maintains its own commitments to polar research and a complementary interest in international co-operation.** Although Canada must be vigilant about defence, its sovereignty claims, and its competitive position in polar technologies, it would not be realistic or productive to view the Arctic as an arena of direct competition where several nations are striving to outpace one another. There are more opportunities than dangers for Canada in the increased international scientific activity in the North.

The greatest concern for Canada arising from these developments is not whether we will be "beaten" in arctic research by other nations. It is whether we will continue to be a strong force in international polar affairs and acquire the sophisticated knowledge necessary to benefit domestically from the increase in world knowledge about the polar regions. Non-arctic nations are not constrained by domestic northern concerns and can focus exclusively on advancing world science when determining their polar research activities. The increasing influence of these nations, and Canada's aloofness from the antarctic research community, means Canada's influence in directing international polar research to subjects and issues of domestic importance is declining.

While southern Canadians often have difficulty in isolating specific lessons that can be learned from other polar nations to the benefit of northern Canada, northern aboriginal peoples perceive a rich web of political, social and economic advantages to increased contacts and co-operation in the circumpolar world. Canada's aboriginal peoples were leaders in the international initiatives that led to the creation of such bodies as the Inuit Circumpolar Conference, Indigenous Survival International, and the World Council of Indigenous Peoples. The steadily increasing influence of these organizations in the world of international polar and aboriginal affairs has served to awaken many southern Canadians to the importance of the international Arctic.

Whether promoting co-operation or dealing with conflict, the strength of Canada's voice will be related closely to the state of our knowledge of the polar regions and to the perceptions that other nations have about Canada's commitment to polar research and the general importance it attaches to arctic issues. Our greatest need is to increase our inadequate knowledge of the Canadian North and the polar regions, and to develop a sound **institutional** basis for an on-going working relationship with governments and research institutes in other countries engaged in polar research.

Until about fifteen years ago, Canada was a major supporter of an excellent international science information system, operated by the Arctic Institute of North America, that made accessible up-to-date information on the research activities of other countries in the Arctic, and published results of their findings. Increased industrial activities in arctic Canada led to a number of other science and technology data and information systems specializing in polar subjects. In recent years these information systems have been curtailed, and some have been discontinued. Today, even though the Arctic is of increasing importance and there is greater international activity than ever before, it is more difficult to obtain up-to-date comprehensive information in Canada about international polar research. This problem compromises the ability of Canada to develop and maintain world class polar research and scientists.

4.4.4 A long-term commitment

The members of the Working Group have been mindful that this is not the first inquiry into the state of northern research in Canada or, indeed, into the possibility of creating a Canadian polar institute (see Chap. 6). In the past forty years, there have been many public and private studies on this subject. Most of these studies have called for an increased or sustained public commitment to arctic science. Some positive actions were taken. The Act of Parliament that created the Arctic Institute of North America (Section 3.1) commits it to serve as Canada's national polar institute, although no arrangement was made for its on-going financial support or its accountability in that role. Despite the past studies and an increase in the number of institutions involved in northern research, - or perhaps because the actions taken as a result of the studies did not solve the problems - the Working Group found a sense of dissatisfaction in the research community and among those who make use of research findings.

One of the principal reasons for Canada's uneven record in polar research, and the many problems discussed above, is the failure of institutes supporting polar science and technology to maintain the kind of long-term commitment to northern knowledge that world-class modern science demands, and which other nations are demonstrating to an ever increasing degree. It is not that we have been too restrictive, or not allowed our scientists enough freedom, or that they have studied the wrong things. If there is any one main reason for our shortcomings, it is our **collective** failure to **sustain** our polar research efforts, either financially or institutionally.

The real value of the federal government's expenditures on northern research has been declining steadily since the early 1970's. While over 35 Canadian universities are members of A.C.U.N.S. and support some individual research activities, no Canadian university includes a commitment to polar work as part of its corporate identity. As a consequence, the extent of the institutional academic northern involvement tends to coincide with the arrival and departure of individual scholars and the variations in emphasis or enthusiasm of the research granting agencies. Canadian industry, especially the petroleum industry, has spent more than one hundred million dollars on polar research and polar technology over the past fifteen years, but directed almost all these funds to immediate operational problems or resource assessment activities defined by short-term investment cycles. The recent collapse of non-renewable resource investment in the North has effectively interrupted industrial support of polar research, dispersed an important and large network of researchers, and led to the dismantling or non-use of arctic technical laboratory and field facilities and equipment.

In many areas of Canadian science, a conscious national commitment to sustained research support is not crucial, because over time the utility of the research results, the interest of the academic community, the public need for information, and the actions of the market-place will work to maintain national support for science in various subjects at a reasonable level in relation to all the other demands on our national science resources. Following this reasoning, it may be claimed that, if support for arctic research is declining and the best scholars are not tempted to pursue polar studies, this may be because arctic science is declining in net national importance or urgency. There are, however, some areas of research where the forces of the "scientific market-place" do not apply because the national need for knowledge cannot be reflected in economic terms or academic priority. This occurs where the "pay-back" from scientific findings is long-delayed or the beneficiaries unknown, or where the costs of not keeping scientifically up-to-date cannot be easily quantified and compared with the costs of the research. Areas of science where these criteria apply include space research, some aspects of defence technology, environmental control and some areas of medical research. They apply also, importantly, to polar research. For many areas of polar research, the long-term risks of not pursuing new scientific knowledge are more fathomable than the short-term benefits of the results of the research.

The Working Group believes that polar research in general, and research in many natural and social sciences in the Canadian North, are subjects where sustained research activity can and must be justified separately from evaluation of the success in finding immediate solutions to current urgent or costly problems. The social, economic, environmental and geopolitical issues that will have to be faced in the decades ahead will require action based on reliable knowledge and understanding of arctic and polar physical characteristics, resources, and peoples and this justifies a national sustained commitment to polar research.

Such a commitment must include the kinds of infrastructure needed to give a collective purpose or assurance of continuity to these activities. As a nation, we have some catching up to do. Canada no longer has a current world-class polar library, whereas we used to have two. Several government and university research stations in arctic or sub-arctic Canada are currently closed or inactive; the ones still operating are in a precarious financial position. Canada's participation in important international co-operative research projects in the polar regions is weak and, except in some areas of geophysics, we have left research on the Arctic Ocean to other nations.

The challenge is not simply a matter of increasing the total financial resources invested in polar research. The more fundamental challenge is to develop a sustained conviction of the importance and relevance of arctic knowledge, and a commitment to the co-ordinated institutional support as a result of that conviction.

5. TRENDS AND NEW DIRECTIONS IN POLAR SCIENCE

Although northern Canada and other parts of the polar regions, including Greenland, northeastern Siberia, and most of Antarctica, were among the last extensive terrestrial areas systematically mapped and investigated geologically and biologically, by about 1960 the reconnaissance and exploratory survey phase of most fields of science in the polar regions was coming to an end. Until that time, the emphasis of northern and polar science had been on mapping and description of **what** was there and **where** it was found. New data, from new regions, was a principal objective of research in the physical, biological, and human sciences. Scientific efforts and expenditures in northern Canada and the Arctic were concentrated on the areas of geological, geophysical and hydrological surveys, taxonomy of flora and fauna, widely spaced reconnaissance studies of oceanographic characteristics, observations of meteorological phenomena, indigenous cultures and societies, population and demographic statistics, and descriptions of archaeological sites and their contents. During this period, polar science was confined within the major disciplinary fields that classified science in temperate regions. Some beginnings were made in systematic organization of recorded information, but the main goals in most fields were to produce reports which portrayed as accurately as possible a "snap-shot" of the northern and polar lands and their characteristics. Little attention was paid to dynamic change except as a problem for the observer. The time and space scales of either natural or social phenomena were incidental to accurate description.

During the 1960's, a distinct change of emphasis in polar science became noticeable. The kinds of studies commonly undertaken in northern Canada, the Arctic Ocean, and Antarctica took on a different purpose. Less attention was paid to careful description and more to how things got the way they are. The popular phrase became "process studies", and it applied to the evolution of land forms or the explanation of currents the Beaufort Sea as well as to the evolution and history of native cultures. The technologies of field research advanced rapidly during this period, especially in the geosciences and the atmospheric sciences; remote sensing, sensitive field geophysics, geochronological dating, automatic recording equipment added new dimensions to the data collected, and led to new interest in the inter-relationships between biological and inorganic processes. Space and time scales of study gradually increased. The new techniques opened the possibility of collating data over large regions, and led to large integrated, internationally co-ordinated research programmes. The first of these, the **International Geophysical Year 1957-58** , was planetary in scope but laid particular emphasis on both polar regions. Like its predecessor the **International Polar Year** seventy-five years before, the **"IGY"** brought polar science back into the mainstream of world science. It ended what had been three generations of comparative intellectual and geographic isolation for polar scientists.

The advances in transportation and communication, research techniques, data handling and scientific understanding that made the International Geophysical Year a success also made possible world-wide integrated studies in other fields of science in polar regions. IGY was soon followed by the International Biological Programme (IBP) and the International Hydrological Decade (IHD), and by a long list of increasingly sophisticated studies and large-scale experiments, international and circumpolar in scope but carefully focussed in scientific content and purpose. Although much good work was still being done by individual researchers pursuing independent studies, it is probably true that during 1960-1980 the main advances in understanding of the natural phenomena of polar regions came through co-operative international programmes. A partial list of such programmes, in which Canadian scientists took part and which had significant northern or polar components, shows by their titles the types of basic scientific problems that received major international attention :

Tundra Biome Project (of the International Biological Programme);

International Geodynamics Programme;

Upper Mantle Programme;

International Magnetospheric Study;

Northern Basins Research Network (of the International Hydrological Programme);

International Study of the Fluctuations of Glaciers;

Polar Experiment (POLEX) of the Global Atmospheric Research Programme;

Arctic Ice Dynamics Joint Experiment;

Marginal Ice Zone Experiment;

Bering Sea Experiment;

Northern Birch Forest Ecosystem Study;

Arctic Aerosol Sampling Network;

Research programmes of the Migratory Birds Convention Act and The Polar Bear Treaty.

Man in the North Project - Arctic Institute of North America

At the same time that international research was focussing on the basic problems of scientific processes in polar regions, there was a surge of more applied and issue-oriented studies that related directly or indirectly to resource development and exploitation, social and political issues, and questions of engineering, safety and health. These studies were carried out on a national basis, often with a local focus. They were funded either by private sources interested in the development of non-renewable resources or by government agencies concerned with obtaining the knowledge needed to ensure responsible resource management, the protection of the environment, and positive socio-economic changes in the event that rapid large-scale industrial exploitation of northern resources occurred. These activities have resulted in important advances in arctic technologies and have added much to the scientific information base of northern Canada and other northern circumpolar regions. In themselves, however, they have added relatively little to the basic understanding of northern or polar phenomena or conditions.

The combination of international projects addressing major scientific problems and local or regional information from mission-oriented studies, together with developments in world science as a whole, have led in the past few years to a more integrated scientific understanding of the polar regions. Some likely directions for future research in the polar regions resulting from this new understanding are outlined below.

Observations in high latitudes are essential for modern research in **space physics,** for it is there that the interplanetary magnetic field lines approach the Earth at a high angle, and direct observations are possible of the behaviour of the plasma boundary layer caused by the interaction between the magnetic field of the Earth and the "solar wind" energy pervading the solar system. Observatories in Alaska, Greenland, Svalbard and Finland have made significant recent advances in understanding the nature of the magnetosphere that surrounds the Earth, and which has an important influence on the pattern and stability of the Earth's surface energy. The interpretation of these observations is strengthened by complementary data on the behaviour of electromagnetic currents in the Earth near the geomagnetic poles, which lie in Canada and Antarctica. These high-latitude researches have led directly to increased understanding of the behaviour of the Sun itself, the mechanism of solar flares and sunspots, and the studies of the atmospheres of other planets, in particular Venus and Jupiter. Some recent work appears to indicate that electromagnetic phenomena displayed near the poles may have a much greater effect, in both short and long term, on climatic and biological phenomena of the Earth than had hitherto been evident. Research of arctic and antarctic magnetospheric processes is thus an essential part of modern world science.

Studies of the **polar atmosphere** have recently revealed features of significant importance to the world as a whole. The weakly ionized upper atmosphere, or **ionosphere,** is strongly influenced by the Earth's electromagnetic field in high latitudes (one spectacular visual effect is the aurora), and these disturbances propagate across lower latitudes between north and south polar regions. The disturbances have important effects on communications and navigation equipment, and are of great practical importance, both military and civil, as well as being of great scientific interest. The different colours in the aurora are due to different mixtures of gas molecules, and thus the aurora itself can be used as an analyzer and monitor of upper atmosphere chemistry. Ionosphere studies are undertaken in all arctic countries, but they would be incomplete without co-ordinated studies in south polar regions. Canada has played a prominent role in "conjugate" (i.e. paired north polar and south polar) studies of ionosphere phenomena since the IGY; observing stations at Roberval, Kuujjuarapik (Poste-de-la-Baleine) and Iqaluit have been essential to the international researches in this field. Much has been learned in recent years by studying the aurora from above from orbiting satellites, as well as from below through ground-based stations in the Arctic and Antarctic.

At lower atmospheric levels, research has been traditionally directed toward the understanding of **polar climate** and **weather,** and the improvement of weather forecasts. Under the Global Atmospheric Research Programme (GARP - 1968-1976), which developed into the current World Climate Programme (WCP), a number of high-latitude experiments and special sub-programmes have been carried out with the aim of understanding the processes by which atmospheric and planetary heat was lost in polar regions and its effect on weather patterns and climatic stability. Questions relating to the radiative transfer between the Earth's surface, the atmosphere, and outer space, to the climatic implications of aerosols and trace gases and to the momentum coupling between moving atmosphere and different types of surfaces have in many cases been more successfully studied in the Arctic than in lower latitudes. These studies are important to climate and weather problems on a world scale.

Other topical questions engaging atmospheric sciences in polar regions include : the long-range transport of pollutants from industrialized regions to the Arctic; the distribution of increased carbon dioxide in different latitudinal zones and the effect of such increases on the climate in northern zones (in general, the expected effect on temperature and precipitation will be greatest in the sub-Arctic); the thinning or patchiness of tropospheric ozone in high latitudes; and the effects of such changes on hydrological systems, sea ice, terrestrial and marine ecosystems and humans. Major advances are being made in understanding the characteristics of low-temperature air pollution from urban or industrial sources, which is becoming an increasingly severe and difficult problem with the increase of automobiles and power plants in the North; and in the effect of surface weather on the distribution and movement of sea ice.

In **physical oceanography,** general knowledge of water masses and their dynamics in the Arctic Ocean, north Atlantic and Bering Sea and the Southern Ocean have led to specific and important questions of the degree of inter-annual variability of circulation patterns, the net heat and mass transport, and the response relationship between variations in atmospheric climate and variations in oceanic climate. These questions have profound implications for our understanding of global heat balance and climate change, which in turn affect the stability of marine ecosystems, the management of living resources and the distribution of pollutants. These in turn are important to the planning of northern (and Antarctic) development and transportation systems. Advances on these problems will require the collection of arrays of sophisticated data over a number of years, supplemented by carefully designed large-scale investigations, particularly in critical areas such as the northern "choke points" - Fram Strait, Greenland Sea and Bering Strait-, in the south, Weddell Sea and Drake Passage. Such studies require international co-operation and the co-ordination of a number of specialists and services over an extended period. Although the specific areas mentioned above are not adjacent to Canada, their study is vital to Canadian interests. In fact, Canada has a more direct national interest than any other country in understanding the nature and behaviour of the water and ice in Fram Strait between Greenland and Svalbard, because what happens in Fram Strait appears to be a major determinant of sea ice conditions throughout all of arctic Canada. For this reason, Canadian scientists have been active in the planning of all the major polar oceanographic studies, and have participated in research programmes in Bering Sea, Greenland Sea, and Antarctic seas, as well as those close to Canada.

Important questions are emerging with regard to the **movement of chemicals** into and out of the polar regions, by the oceans or by a combination of oceanic and atmospheric transport. The uniquely stable and stratified character of the Arctic Ocean, the formation of "deep water" in the Greenland Sea, and the contrasting circulation of the Southern ocean, whose "bottom water" descending at the edge of the antarctic continent creeps northward beneath the Atlantic and Pacific Oceans until it reaches north of the Equator, have influences on global distribution of chemicals that appear to be important to the world environment and biological systems, but which are so far poorly understood. The Arctic Ocean is becoming the final repository for most of the industrial world's persistent toxic chemicals, which ultimately get washed into the Atlantic ocean from almost all of industrialized North America and Western Europe, then carried northward by the Gulf Stream and North Atlantic Drift to the Arctic Ocean, where they are reinforced by chemicals from Siberian rivers, and slowly deposited in quiet waters under the ice which prevents decomposition through the actions of sunlight and gaseous exchange. To this chemical load are added airborne pollutants, transported across the Arctic Ocean basin from industrial sources mainly in Europe and western Asia, which cause the familiar man-made "arctic haze". The air chemistry monitoring station established in 1986 at Alert will enable a quantum jump forward in our knowledge of the chemistry of arctic air masses. This station is in part complemented by the Clean Air Facility at the South Pole, a unique laboratory that monitors the quality of the world atmosphere by sampling the air that has risen to high altitudes over the tropics and migrated slowly to Antarctica (see page 32), and thus is as far as possible from direct contamination by industrial sources. Such measurements, possible only in the polar regions, are of world-wide importance.

Knowledge of polar **marine biology** has advanced in spectacular fashion in the past decade through integrated studies. The BIOMASS program (Biological Investigations of Marine Antarctic Species and Stocks) has been one of the most comprehensive studies of a regional ecosystem carried out in any ocean, and has provided new understanding of nutrient flows, inter-species and inter-trophic relationships, and the variability of populations that are not only essential for resource management in the Southern Ocean, but are directly relevant to the understanding of arctic marine ecosystems and resources. The coastal biological programme of the Outer Continental Shelf Environmental Assessment Program in the Beaufort Sea of Alaska has given a new and integrated picture of an arctic coastal ecosystem, particularly with regard to species and population diversity in relation to different bottom conditions and current regimes, and has investigated processes and rates of recovery or recolonization after disturbance. The PRO MARE project in the Barents Sea promises to give science its first extensive quantitative information of the spatial and temporal distribution of nutrient cycling, and thus the productivity at different trophic levels of an extensive area in arctic waters.

These programs have produced results of direct practical importance for resource development and environmental protection, and they also add to fundamental scientific knowledge. Canadian marine biologists are building some of their most important current research on the results of these and related studies, and extending them to Canadian problems. Among important questions being tackled are the role of eddies and upwelling in causing variable nutrient supply in Labrador Sea, North Baffin Bay, Lancaster Sound and eastern Beaufort Sea, the causes and timing of "blooms" of algae, the ecological importance of biota that attach themselves to the underside of sea ice, and the effect of wind in maintaining polynyas and thus the productivity of the ecosystem.

Many areas of polar marine science of great significance to Canada in the immediate future relate to the animals of direct importance to northern residents. **Marine mammals** and **seabirds** are important as human food and as apex consumers in the arctic ecosystem. Despite generations of observation by Inuit and spasmodic study by southern scientists in the past hundred years or so, the biology and population dynamics of arctic marine mammals and birds are poorly understood. Issues of conservation and resource management, intertwined with northern socio-economic and political development demand a better scientific understanding, incorporating Inuit knowledge, of the population dynamics of major species.

Most arctic marine populations appear to be in a state of rapid change, and different species are changing in different ways, perhaps from different causes. For example (i) some species or populations appear to be experiencing reproductive failure or anomalous mortality; (ii) others appear to have recently expanded and are over-exploiting their food resources so that a "crash" may be impending; (iii) still others have been severely reduced by hunting or other human action and their recovery is slow or doubtful, while (iv) still others, currently exploited by humans, appear to be maintaining their population, and may even be strengthened by responsible hunting. Research to explore these kinds of questions clearly requires more than routine field observations. New technologies, such as radio collars, acoustic surveys, and experiments in captivity are coming into use. Recent research on the distinctively different concentrations of industrial organic pesticides that are found in the livers of polar bears in the eastern, central, and western Canadian Arctic is an example of the kinds of study needed to provide knowledge for the intelligent management of these irreplaceable resources. However, at the present stage of investigation, new research of this nature is full of surprises, rarely of answers.

Perhaps some of the most exciting changes in polar sciences in the past decade have been in the disciplines of **geology** and **solid earth geophysics.** The revolution that has taken place in geological thinking in recent years includes plate tectonics, planetary thermodynamics and the role of biological processes in geological phenomena. Crustal and geological research in high latitudes has in some cases been critical to the evolution of modern geological concepts. The fact that the arctic regions consist of large land masses surrounding a small central ocean while the antarctic regions constitute an extensive ocean area surrounding a central continent, plus the fact that the regions include the geomagnetic and rotational poles, make careful studies of high-latitude land masses and ocean basins of special significance to understanding of crustal and geological history. The new understanding is altering the views on potential mineral and petroleum resources, evolution of ecosystems, and climatic history.

Current interpretations link the present configuration of the arctic regions to movements of crustal plate fragments across the Pacific Ocean, and the opening of the Atlantic Ocean. Alaska and Yukon are a collage of some 50 separate crustal fragments, properly called tectonostratigraphic terranes, that were originally in equatorial latitudes and which have been pressed against the mass of North America during the past 220 million years. Modern earthquake and volcanic activity are evidence of on-going movement. The western basin of the Arctic Ocean (the so-called Canada Basin) began opening about 165 million years ago. Sometime later a splay of the active mid-Atlantic fracture created Baffin Bay between Baffin Island and Greenland, then stopped. About 60 million years ago the Atlantic fracture extended between Greenland and Svalbard and split the continental shelf north of Siberia, creating the, still slowly widening, Eurasian Basin of the Arctic Ocean and isolating the peculiar submerged ridge, the Lomonosov Ridge, that crosses the present Arctic Ocean and divides it into two separate parts. During all this time, the continents themselves did not remain stationary. What seems to have been fairly fixed on this part of the globe is the "hot spot" under what is now Iceland. Combined geophysical and geological studies in the past three years have uncovered an intriguing trail of progressively older evidences of volcanic activity, extending from present-day Iceland across Greenland and into the Arctic Ocean on the Alpha Ridge and suggesting that the whole northern part of the North American crustal plate slid over and away from the present position of Iceland in the past 150 million years. The carefully-measured present-day rate of widening of the North Atlantic Ocean is compatible with such a motion and direction.

These, and other evidences of the history and dynamics of the arctic regions in the Barents Sea, Chukotka, etc., have led to concepts of crustal processes that are helping to explain puzzling, but less well displayed, phenomena in other parts of the world. In the Arctic, they are beginning to assemble a picture that is promising new and more positive explanations for the occurrence and distribution of mineral and fossil fuel resources, for predictions of earthquakes, and changes in sea level.

The antarctic regions have had a similarly dramatic geological history with the continent separating from what is now Africa, India and South America, and migrating in two blocks to its present position over the South Pole. The study of antarctic geology and tectonics is important to the rest of the world, including arctic countries, because, as the least geologically active of continents at the present time, Antarctica provides evidence of geological evolution that helps explain features in other areas.

Many of the new insights into the nature of polar processes have come from studies of **permafrost.** The investigations of frozen ground, which until recently had been a rather esoteric branch of physiography or an adjunct to trial-and-error engineering, has emerged into a distinct science, with theoretical, mathematical, and extensive technological and applied aspects, and, at least for a few years, large budgets to match. Petroleum development, transportation, and construction in the Arctic encounter major, expensive problems that cannot be satisfactorily solved by rule of thumb or an increase in engineering safety factors.

To develop the techniques and equipment to overcome these problems, some fundamental research into the nature and effects of freezing and thawing of natural materials was necessary. Permafrost sciences, and the geomorphological and glaciological sciences that were associated with them, have been unusual among polar sciences in that areas of fundamental physics and physical chemistry have evolved from attempts to solve urgent practical problems.

The emergence of this subject as a science in its own right is shown by the 1983 International Conference on Permafrost, which attracted 910 delegates from eleven countries, and the recent organization of the International Permafrost Association as a major professional society, with its secretariat in Canada. As understanding of this distinctive polar phenomenon has developed, major scientific concerns about frozen ground have focussed, not exclusively on its stability and mechanical properties, but on questions of rate of response to climatic variations, problems of polluted ground ice, and the cycling of chemicals and nutrients through the active layer.

With the important exception of the International Biological Programme 1967-72 and the work that followed directly from it, studies on the **terrestrial biology** of the polar regions have rarely been organized into major international or interdisciplinary projects. There is a great deal of data still to be obtained by direct field observation, and much of the most essential work is carried out by small parties and simple methods. Researchers in terrestrial biology have been hit particularly hard by the funding restrictions that have affected all polar sciences, and many important arctic and antarctic biological problems are recognized but are not at present being addressed.

During the past fifteen years, an increasing number of **land-based and aquatic biological** studies have been related directly to environmental protection concerns or the management of renewable resources for use by northern residents. This work has increased the base line data on populations of major species and their response to hunting and to disturbed habitats. Most such studies, however, have not been continued long enough or thoroughly enough to provide a confident understanding of the factors affecting population change or habitat sustainability.

Northern Canada, like the northern regions of most arctic countries, is in a stage of subtle but serious transition with regard to its impact on wildlife and vegetation, and this transition is altering priorities for biological science. Until recently, the main human effects were from hunting, trapping and fishing, which removed individual animals that were relatively high in the food chain. Present and anticipated future impacts are of a more subtle and pervasive kind : alteration and loss of habitat, resulting in changes in vegetation; introduction of chemicals that affect reproduction; interference with migration patterns and disturbance in a variety of ways through increased human activity. These are affecting whole ecosystems rather than selected valuable species. The problems raised by such impacts have directed the emphasis of modern polar biological research toward identification of factors that affect biological productivity at low energy levels, and the role of the ecosystem itself in maintaining its own habitat. Recent work on the cyclical build-up of natural toxins in vegetation and its role in controlling lemming populations, on the role of atmospheric gas exchange on the availability of nutrients, and on the effect of variations of ice and snow cover on the productivity of northern aquatic environments are examples of new directions of research that incorporate both physical and biological sciences.

Biological studies of the polar regions are essential to many of the questions in the forefront of world biology today. The low level of available solar energy (in places less than one-tenth that of the tropics), the extreme summer-to-winter variation, and the fact that water, essential for all life on the planet, is commonly in solid form, have resulted in specialized ecosystems whose basic processes can be studied more clearly than in more complex and luxuriant parts of the planet. Spatial variation of biological vigour in polar regions is extreme - a few places are comparatively rich and productive while adjacent areas of apparently similar environment are nearly barren. The study of ecotones, or "patch dynamics" to investigate the processes and relationships at the boundaries between areas of contrasting biological nature is an important component of the new biology, and the polar regions provide many of the most critical examples. The extensive peatlands and muskeg of northern North America and Eurasia contain the world's largest reservoir of biologically-fixed non-oxidized carbon and are major generators of planetary methane, an important factor in causing change of climate. Thus studies of arctic vegetation and decomposition are essential to the consideration of the natural and human-caused (through fossil fuel combustion) influences on climate change.

An example of the essential integration of polar biology with problems and happenings in the rest of the world is provided by the specialized studies of flora and fauna that have been undertaken by all arctic countries in the wake of the 1986 accident at the Chernobyl nuclear power plant in the Soviet Union. Studies of the radioactive fallout from the atmosphere, and the incorporation of radionuclides into lichens and other vegetation, subsequently into reindeer, caribou or lemmings, then finally into humans, were carried out first in Scandinavia, then in USSR, North America and Greenland. The need to make political and regulatory decisions about the safety for human consumption of potentially contaminated meat lent urgency to these studies but they could not have been possible without on-going research and expertise in arctic botany, zoology and ecology. At the same time, this on-going research has itself added importantly to the understanding of polar biological, ecological and atmospheric processes.

Research in the **human sciences** in the polar regions is, except for some specialized biomedical investigations and studies of the history of exploration in the Antarctic, entirely arctic. Systematic studies in human and social sciences in the Arctic have on the whole lagged behind those in the natural and applied sciences, and there have been few major thrusts or concerted programmes. The series of Conferences on Circumpolar Health have, however, played a valuable role in exchanging information and promoting informal collaboration in the polar medical and behavioral sciences.

In Canada, deliberate steps by funding agencies and by federal and territorial bodies over several years to encourage serious research on human and social subjects are slowly beginning to have results. About one-third of the studies supported by the federal Northern Scientific Training Programme and by the Science Institute of the Northwest Territories are in fields that can loosely be called "social science". Many of these are still in the descriptive or data gathering stage, or are oriented to define problems on which policy or corrective action should be taken. Others are what might be called "salvage science" - to record information on linguistics or native oral history before it is lost under the pressures of cultural change, or to have a quick but careful look at archaeological resources before the evidence is removed by development or by tourists. This work is essential and over-due. It is gathering irreplaceable information, helping to enlarge the interest in polar areas among the social sciences community, and establishing among governments, other scientists and the public an appreciation of the value of the human-oriented disciplines in the polar regions. But leading researchers have pointed out that social sciences in the arctic regions have in few areas reached the levels of sophistication that leading studies of the same subjects have reached in other parts of the world.

Some trends appear to be evident. In the social sciences, as in the natural sciences, the advances in knowledge from arctic regions are increasingly integrated with findings from other parts of the world. But because the results of arctic research in human sciences obviously have direct importance for northern residents, the distinctive features of arctic social behaviour, health, or culture studies in comparison with those found in other latitudes, become a basis for policy and corrective action. Some current areas of study show the emphasis on human response to arctic environments :

(i) the fact that the leading causes of premature death in arctic regions are not disease or malnutrition but socially-related causes such as suicide, homicide, accidents and alcohol-related incidents;

(ii) problems of accumulation of trace metals and man-made toxics from both natural "country foods" and imported foods;

(iii) health and psychological problems of indoor air pollution (including the pollution in traditional tent or snowhouse housing, now disappearing but with a serious residuum of effect among senior citizens) and their implications for housing design, community planning, and organized social behaviour;

(iv) the effects and opportunities of modern electronic and computational systems among northern native cultures that have not been obliged to reduce their thought processes to the linear restraints of a written language but can move their communication processes directly into the multi-dimensional computer age;

(v) the clashes between and reconciliation of value systems that view resources as exploitable commodities with value systems in which humans view themselves as integral parts of the land, within political and economic processes that attempt to give each system specific areas of priority;

(vi) the social and welfare aspects of human response to environmental stress in the Arctic.

In these and related areas, some of the most articulate calls for new knowledge come from the native peoples of the North. It is reasonable to expect with confidence that, in the future, native northerners will increase their influence and, in some areas, take the lead in research in arctic social sciences. The number of students in northern social sciences in Canadian universities is still small and limited because of lack of support for such studies. However, among those presently studying in these fields are a number of native students from northern Canada. They are tomorrow's natural leaders in these important fields of science.

In the future,more and more **polar research in general** will be conceived and supported not to investigate arctic or antarctic phenomena for their own sake, but because of their importance to scientific problems of the world as a whole and because precise knowledge of polar regions is important to social and economic development. Internationally coordinated programs designed to address major scientific problems promise to be a continuing feature of polar research. Some of these will be specifically arctic in character, such as the proposed Greenland Sea Project currently being considered by the Arctic Ocean Sciences Board but whose results promise to be significant for understanding of the behaviour of oceans in both hemispheres. Others will be integrated with world-wide studies, such as the Polar sub-programme of the World Climate Research Programme of the World Meteorological Organization, or the polar contributions to the International Geosphere-Biosphere Programme presently being planned by the International Council of Scientific Unions. Participation in these major international programmes is not only of value to world science, it also serves an important role in ensuring that arctic science is of a quality, rigour, and originality equal to science in orther parts of the world. As a country which is more than half "arctic", Canada stands to benefit from such participation and has a responsibility, among the community of nations, to contribute to the advances of knowledge and the benefits from science. At the same time we must ensure that we foster, and maintain, an adequate national and local science programme in the North, responsive to local needs and producing results that are useful to all Canadians. There is no conflict between the international and the local perspectives in polar science. Indeed, good science cannot be achieved at either level without the other.

6. PREVIOUS REVIEWS AND RECOMMENDATIONS REGARDING NORTHERN AND POLAR SCIENCE

There have been several assessments and examinations of the state of scientific knowledge pertaining to the Canadian north and the need for research as a foundation for northern political and economic policies. Both polar research and the creation of a national institute have been subjects of parliamentary debate several times. Studies of northern science have been undertaken by government agencies, professional societies, industry and public interest groups. Many of the reviews have considered the organization and management of Canadian science in the North and the polar regions, how it is supported, and what has happened to the scientific information produced. Nearly all have made recommendations for improvement. It would appear that few of the recommendations have been implemented in a systematic way, although informed reviews and recommendations led ultimately to : (i) the creation of the Arctic Institute of North America (1945); (ii) the formation of the Advisory Committee for Northern Development (1948); and (iii) the establishment of the Northern Scientific Training Programme (1961).

These reviews present a very valuable reference and running commentary on the progress and weaknesses of polar science in Canada. The Working Group studied many of them, and considered their comments and recommendations in the light of the present situation and what might be expected in the next ten years.

Brief summaries and references of some of the more pertinent reviews and examinations of northern and polar science in Canada and other countries are given in Appendix C.

7. FINDINGS : NEEDS NOT SATISFIED BY THE PRESENT SITUATION

The Working Group has identified several areas where the present system of science support is not meeting what we and others believe to be important Canadian needs regarding northern and polar science, technology, and information. While problems are often expressed in terms of inadequate resources for science or inadequate influence by northern residents on research and development policies in the North, the Working Group is of the opinion that many of the most serious shortcomings are not likely to be overcome within the present science support and institutional structures, even if more financial resources were made available and even if more power were given to northerners. Some real changes in approach to science programmes, involving the recognition of the linkages between scientific activities and local issues in the North, will be required before Canada can achieve a sustained, first-class, balanced polar science and research programme.

The following are some of the important needs not at present being adequately met, with regard to northern and polar sciences in Canada.

7.1 A Continuing Commitment to Northern Science

A sustained, conscious national commitment to increasing the knowledge about northern Canada and the polar regions, and to ensuring that such knowledge is relevant to the needs of present and future Canadians and accessible to them, is needed if Canada is to overcome present problems and deficiencies in the field of polar research.

Despite a large number of individual activities and the efforts of government agencies with responsibilities for increasing knowledge of the North, Canada has not recognized as a national priority the need for or value of maintaining and increasing its fundamental and applied knowledge of the northern two-thirds of the country, or of the polar regions generally. The lack of a sustained political and public commitment to knowledge of our North is a principal reason for the unbalanced nature of Canadian northern and polar- related sciences, and it lies behind many of the problems noted in Section 4 above and the specific shortcomings noted below.

7.2 A Co-ordinated Information System for Polar Science and Technology

Canada needs a comprehensive, modern information and communication system covering all major areas of research and technology relevant to northern and polar regions.

There are already a number of specialized arctic-oriented data bases and bibliographic systems dealing with important parts of northern and polar science, and some general arctic information networks have developed and been quite successful over the years. Much of the information related to arctic science and technology is integrated into the international data networks and particular subject areas. Nevertheless, dismemberment and inaccessibility of information about current research and its findings, incompatibility between various systems already in place, and difficulties of establishing contacts among researchers in various fields and different institutions remain major problems and a handicap to the progress, co-ordination and effectiveness of Canadian research in northern and polar regions.

The technology of information systems and bibliographic co-ordination is advancing rapidly. Some Canadian data systems and library services devoted to northern subjects are modernized, and state-of-the-art, but others are not. An up-to-date, comprehensive and compatible northern and polar science information and communication system cannot be expected to evolve naturally from the various sectorial or subject-limited systems presently in use in Canada. It must be deliberately designed and implemented.

7.3 Science Relevant to the Needs of Northerners and the Involvement of Northerners in Polar Research

Northern and polar scientific activities in Canada are inadequate in that they do not provide northern residents with the information or knowledge that they need to address the various issues that confront them. Northern residents do not have a just or adequate influence in determining northern science priorities or resource allocations, and are given insufficient incentive or encouragement to participate directly in northern science.

An important need is to increase the focus of activities in the natural, industrial and social sciences in the Canadian North into areas of enquiry most relevant to the peoples of the North. Such a change is necessary to give northern residents a greater influence in the planning and control of the funding of northern research and circumpolar or bi-polar studies, without detracting from the research needed in the light of broader national and international interests. Attention needs to be given to the availability of scientific information, from studies in all of Canada as well as of the polar regions, to all northerners who need it, in a form in which they can use it. Furthermore, there is a need to increase the interest of northerners themselves in scientific studies, and to encourage them to acquire the scientific qualifications that will enable them to participate at all levels in world-class research on subjects important to them.

7.4 The Identification of Research Priorities and Areas of Scientific Weakness

Canada needs a mechanism through which the general state of polar research in Canada can be monitored, the areas of most important or pressing research can be identified and the provision of resources for scientific study in fields where the results are likely to be most beneficial or stimulating to northern or national issues or to the growth of world science can be encouraged. Such a mechanism should act

as an on-going point of contact between the polar research community in Canada and decision-makers in government.

The Working Group is aware that high-quality science cannot be maintained if it is constrained excessively by pre-set goals - effective research must include a pursuit of new knowledge for its own sake. At the same time, it is in the interest of Canada to ensure that support be given to the study of those areas where new knowledge will be of most value to national, regional and local issues in the North or the advance of world science.

Scientific activities in the Canadian North are becoming seriously unbalanced. Canada tends to support only established expertise and proven competence and has little capacity to strengthen areas that are scientifically weak. The competition between science undertaken in the North and that done in the rest of Canada for the same research funds does not help to direct northern science to the most urgent scientific needs of the North itself. Northern natural, socio-economic and cultural conditions demand a multi-disciplinary approach to the most important science in those regions; such an approach is rarely given favourable consideration by the agencies responsible for supporting science in Canada. In some areas of northern study important to Canada, we have been unable to maintain modern scientific competence, and are dependent on the research, and research priorities, of other countries.

7.5 A Canadian Focus for International Polar Research

Canada needs to respond to the increasing involvement of other nations in polar research by creating a focus for communication and co-ordination with other countries regarding international research activities in the polar regions.

It is a simple fact of the increasing maturity of polar science that today there are virtually no significant advances in science in the

North and the polar regions that do not have international components. Canada must meet the challenge of the increasing involvement of scientifically advanced nations by increasing our awareness of their activities and by cooperating with them.

Most countries participate in international polar research through national "academy" type bodies, which Canada does not have. The Antarctic Treaty and SCAR operate as strong coordinating forces for international polar research, but Canada does not participate. Consequently, Canada's ability to influence the international polar research community and to organize multi-agency and multi-disciplinary participation in international polar research is seriously compromised.

7.6 A Focus for Public and Educational Interest in Northern and Polar Science

Despite the appeal that ideas and myths about northern areas and polar regions have for most Canadians, no continuing focus for public interest in the North has been developed in Canada.

Canada has a need for an identified place where anyone, from schoolchildren to schoolteachers to businessmen and consultants, can go for reliable information about northern Canada or the polar regions, both Arctic and Antarctic. The public needs scientific information in a form that can be readily understood; it needs to be able to find out who is doing what, and where to turn for references or contacts. Canadian educational authorities and teachers lack a convenient and authoritative source of information on northern and polar regions. Government and non-governmental agencies and institutes that have northern or polar interests also will benefit from a focus, a rallying point from which they can pursue their objectives.

7.7 Attention to Scholarly Research on Polar Policy Issues

Canada needs to increase the scholarly study of the issues that relate political sciences, law and economics to the natural, social and applied sciences in polar regions.

The Arctic presents a rich and unique area for the study of institutional developments, inter-societal interaction, and legal and political evolution. Topics such as the legal, economic and political responsibilities for uninhabited areas, the study of institutions developed around differing societal value systems, and the economic and legal implications of human response to severe environmental stress raise issues that are fundamentally different from those encountered in traditional studies of political sciences, law and economics. Attempts to impose concepts from temperate regions in the polar world is seen by many as one cause of political controversy in northern Canada.

Scholarly studies of these topics can be difficult to do within government because of their political nature. In Canada, research in policy related areas tends to be undertaken by northern aboriginal groups, such as the Inuit Circumpolar Conference, or private groups like the Canadian Arctic Resources Committee. By themselves, however, such groups have difficulty in sustaining the serious methodical scholarly research that will contribute new knowledge to the political and policy decision-making process for northern Canada. The development within universities and independent research institutions of scholarly studies of polar policy issues, critically reviewed in an international context, would be of great value to Canada. What is lacking at present is a means of sustaining support for such studies.

8. POSSIBLE OPTIONS AND SOME PROBABLE CONSEQUENCES

The Working Group has tried to identify areas where improvements are needed and where present science and technology institutions and structures are judged by a broad range of persons concerned with polar research to be inadequate. In considering how to improve this situation, we considered all possible initiatives that seemed to us to be needed or practical. The following are a number of general thrusts upon which federal action could be based to strengthen or reorganize the institutional structure of Canadian polar science, and some of their likely consequences.

8.1 To Continue As At Present

An attempt could be made to improve by strengthening activities within the present mandate of DIAND with regard to its responsibility for the co-ordination and support of northern science. Other government and non-government science and technology agencies and organizations would be encouraged to promote and arrange their own support and coordination positions according to their particular circumstances and their individual abilities, priorities, and needs.

The main advantages associated with this option would be : the present funding regime would be maintained, i.e. no new funding programmes would be established and additional funds could, when conditions permitted, be obtained and used by any or all agencies; present mandates would not be disturbed; there would be a continuity of present experience and expertise in northern science and technology and its administration.

Disadvantages to this option include a continuing fragmentation and a lack of focus for Canadian research and technology in the polar regions, a continuing tendency to direct public support for science to immediate, short term policy objectives, and the isolation of Canadian polar science from the development of polar technologies and from international developments in polar regions, especially the south polar regions.

8.2 A Co-ordinated Polar Science Programme Within the Federal Government

This option would see the development of a general, co-ordinated polar science programme within and across the federal government that would concentrate on serving and coordinating federal government science needs related to the polar regions, but which would also be responsible for managing government support of universities and other non-governmental organizations engaged in polar research.

Some potential advantages of this option are : a closer linking of the polar research community to federal government policies and priorities in the polar regions; possible savings and greater efficiency in the management of government polar science and research; the provision of a "single window" for universities, northerners and other interests desiring scientific knowledge, contacts, and financial support from the federal government.

Some major disadvantages recognized include : the difficulty of enlisting interdepartmental enthusiasm and support for a separate, comprehensive polar science programme; difficulties in reconciling a new lead role for DIAND or any federal agency in polar research with its current policy of transferring programmes and jurisdictions to northern institutions; further fragmentation of Canada's national science capacity and activities by splitting off "northern" science from the mainstream of Canadian science; a possible need to revise DIAND's mandate to include a responsibility for circumpolar or bi-polar science activities.

An important added difficulty with this option is that neither DIAND, nor any single federal government agency, is generally accepted by the

Canadian polar research community as having the capability to manage and direct science in the Canadian North, even though federal government involvement in polar research is widely supported. Several federal departments are more directly and heavily involved in polar science than DIAND. Northern governments, native organizations and universities would probably not welcome attempts to improve the situation by focussing control and resources on one federal ministry only. While an increased emphasis on polar science, and research within DIAND is desirable, it would address but one component of a national challenge that can only be met by involving and serving a much broader range of interested organizations.

8.3 Increased Support of the Established Territorial and Non-Government Northern and Polar Institutes and Research Centres in Canada

There is no doubt that increased financial support of the non-governmental and territorial government Canadian polar research activities would benefit Canadian polar science and research. However, no existing private institution is well placed currently to assume responsibility for the structural and institutional problems that currently plague polar research in Canada. None, except the Arctic Institute of North America, has the legislative mandate, or the institutional structure, to meet many of the major unsolved problems identified by the Working Group.

The Arctic Institute of North America (AINA) was created by Act of Parliament in 1945. For several decades it served effectively as a national polar institute, closely paralleled by a sister but legally separate institute in the United States. Through research, publications, the assembly of a major international library and reference bibliography, the organization of conferences and the operation of field stations in arctic Canada, the Institute developed an impressive body of knowledge of arctic phenomena and a pool of professional scientists and engineers with arctic interests and experience. The activities of AINA provided much of the scientific background that enabled Canada and the United States to cope with and take advantage of the interest in northern and polar matters that arose during the 1960's and 1970's within resource and transportation industries, federal departments, and military quarters.

Since 1976, however, the Canadian government has not provided core funding to AINA, and the Institute has become dependent on a variety of funding sources, adjusting its activities accordingly. Currently, it is a part of the University of Calgary, and its support comes largely from the province of Alberta and from contract services for arctic information. It has a broad representation of northern specialists on its Board, and among its 1000 members and Fellows. It still holds the most comprehensive polar regions library in North America, although acquisitions have been restricted in recent years. It has one of Canada's most highly developed computerized arctic science and technology information search and retrieval systems, produces the only regular scholarly journal on arctic matters published in Canada, and conducts research in a range of academic subjects at its arctic field stations. After a recent thorough internal review of the possible roles that it might play in the years ahead, AINA has decided to focus its resources on arctic science and technology communications and information.

Direct support by the federal government of the Arctic Institute of North America could, if the Institute wished to accept it and was able to fulfill all aspects of its mandate, meet some of the needs identified by the Working Group, but the capacity of the Institute to accept and fulfill these responsibilities is unproven. It has, in effect, become one of several university institutes competing for scarce funds, although there is still wide support for a broader role and an impression in Canada and abroad that AINA is Canada's national arctic institute. Some of the submissions we received were to the effect that, if the federal government wanted to create an effective Canadian Polar Institute, all that was required was to commit adequate continuing resources to the Arctic Institute of North America, and hold it accountable for discharging all its responsibilities according to the Act of Parliament under which it was created.

The possibility of focussing federal support on existing and emerging territorial science institutions as the main centres of Canadian northern research co-ordination raises interesting and complex questions. Developing these institutions at the same time that the territorial governments are acquiring new jurisdictional and fiscal responsibilities could provide a strong science and research component to the educational, economic and social programmes implemented by the territorial governments. However, the obstacles and problems of having such bodies developed into "national" polar institutes would be many.

The Canadian North is composed of several distinct regions : Yukon, Western Arctic, Eastern Arctic, and the provincial norths. No one region acts as a centre and it would probably be desirable to have several institutes to serve the local and regional needs of the Canadian North. The difficulties of maintaining working relationships with the Canadian and international polar research communities would be considerable. Territorial and provincial institutions naturally focus on local and applied research related to the interests of the residents and economies of their regions, and would have difficulty in maintaining a strong commitment to broader, theoretical, multi-disciplinary circumpolar or international science and research. Although there are pressing reasons for strengthening and encouraging territorially and provincially based northern science organizations, it appears that such bodies could not by themselves serve as a composite national polar institute for Canada.

8.4 Establish and Support a New Canadian Institute for Polar Research

A new national research Institute dedicated to polar science and research could function as the national focus for Canadian northern and polar science, technology development, and education. It could also support the polar activities of federal, provincial and territorial agencies, native organizations, universities and private and industrial activities in a variety of ways.

After careful review and discussion, the Working Group has concluded that a new major research organization with its own facilities, research staff and field programme is not needed and would not, at this time be practical at this time. The reasons include the following :

(i) there already exists in Canada a number of public and private bodies undertaking polar research and a new major research institution, by itself, even if adequately funded, would not be able to address and resolve most of the problems with Canadian polar research and the concerns of northerners summarized in Sections 4 and 7 of this report.

(ii) it would be difficult to obtain the substantial funds needed to build major new facilities and sustain operations over a decade, considering the fiscal difficulties encountered at present by the federal government, which is the only likely source of funds of this magnitude;

(iii) the establishment of a new major institute would be opposed by much of the polar research community and by many northerners, who would see a new institute as threatening to their independence and authority;

(iv) it would be difficult to achieve any consensus in Canada on the physical location of a new "national" but "northern" institute;

(v) at this time of serious policy-related problems in the North, scientific independence and credibility for a new institution created by government to study northern problems may be difficult to achieve;

(vi) Canada already has the legislative basis for a Canadian Polar Institute in the Arctic Institute Act. The establishment of another national body with a similar mandate could raise questions as to why the first one was not used, or what new mandate should be given.

8.5 Comments on Various Options

After consideration of the various issues and findings described above, it is the opinion of the Working Group that :

Option 1, under which most of the problems facing polar science, technology and information in Canada have developed, is, by itself, unsatisfactory. It is apparent that institutional or policy changes, or both, will be necessary to improve the co-ordination, relevance and support of northern science.

Option 2, would be unworkable without substantial changes in the mandates and activities of several federal ministries. Even if implemented successfully, it would not be sufficient to address many of the issues identified by the Working Group. There are areas, however, where increased co-ordination between and more vigorous action within many federal scientific activities in the North are necessary and feasible, but we found no evidence to suggest that the best way to accomplish this would be through the establishment of a single federal programme for polar science.

Option 3, deserves consideration and further exploration, particularly with regard to the Arctic Institute of North America and the established and emerging northern research organisations. As presently organized, AINA would be unlikely to meet all the future needs of Canada in the realm of polar research. There would be problems in convincing the present polar research community and northern institutions to accept AINA as the "national" institute. Nevertheless, in some areas, such as communication and information dissemination, AINA boasts considerable resources, expertise, and experience. At the least, consideration should be given to defining the appropriate national mandate and support so that it can continue to contribute in the most appropriate way.

Option 4, the creation of a major new polar research institute is not considered by the Working Group to be the most effective means for the federal government to improve the state of polar research in Canada. Not only would such a body not be welcomed by the polar research community in Canada, or by northern society, it would not address the most pressing needs facing Canada in respect of the quality and relevance of Canadian polar research. No one institution can address problems as diverse as the involvement of native northerners in polar research, the challenge of increased international activity in the polar regions, the fragmentation of polar research in Canada and the lack of a sense of purpose and direction for polar science within government. The challenge is to support, not supplement, the existing institutional framework for polar research in Canada.

9. CONCLUSIONS - AND PREFERRED ACTIONS

9.1 A Combination of Steps to be Taken

The Working Group believes that the most practical and effective course to improve polar research in Canada and to maintain Canada's position as a world leader in polar research and technology is to undertake a number of modest, economical steps designed to build on present scientific strengths, develop a long-term Canadian commitment to polar knowledge and expertise, provide the existing polar research community with the information support it must have, and increase the involvement of northerners in Canadian polar science and research. We believe action is required in three principal areas :

(i) A national body is needed to provide ongoing contact, at a senior level, between the federal government and those concerned with Canadian polar science and research. This body should be responsible for monitoring the overall efficiency, relevance and quality of polar research in Canada and for measuring the contribution of polar research to the fulfillment of national objectives in the polar regions, as well as to the general development of Canadian science and technology. The body should report to a high-level political authority within the federal government on the general health of polar research in Canada and it should make recommendations respecting the effectiveness of public support for polar research in Canada. It should be responsible for monitoring international developments in polar research so as to measure both Canada's contribution to, and competitive position in, polar science, research and technology. It should act as a principal point of contact between the Canadian and international polar research communities.

(ii) A national, comprehensive, multi-disciplinary information system on polar affairs is required in Canada. This system, which can be built upon the numerous excellent but often specialized libraries, bibliographies and data systems that already exist in Canada, should be one of the world's leading repositories of general information on the polar regions and should be international in scope and character. Efficient methods of access to the system should be developed for the Canadian polar research community and especially for northern territorial governments, aboriginal organizations, and communities.

(iii) A tangible, physical presence is required in the national capital region to facilitate and encourage contact among the many governmental and non-governmental bodies in the national capital that are active in polar science and research or in northern affairs generally. Such a presence, i.e. a building, would be the physical seat or communication point of these bodies. It would serve as a rallying point for the evolution of a "critical mass" of Canadian polar expertise and foster greater intellectual creativity and interaction within the Canadian polar science, technology and public interest communities. It would also serve members of the general public seeking information and exposure to polar affairs.

Accordingly, the Working Group recommends :

(a) the creation of a Canadian Polar Research Commission, accountable to the Canadian government at a senior level and responsible for periodically reviewing the needs and progress of polar research in Canada for recommending steps to be taken by the federal government to improve the relevance and effectiveness of Canadian polar research and for facilitating international liaison and co-operation in the polar sciences;

(b) the establishment, in co-operation with the National Libraries and with provision for continuity, of a Canadian Polar Information System, a comprehensive, coherent multi-disciplinary information and data system of national and international polar knowledge. The system should incorporate or build upon existing data and information systems, use modern data and bibliographic technologies, be compatible with national and international data systems and be accessible to the Canadian polar research community and northern institutions;

(c) the designation of a tangible expression of Canada's polar interests, here called "Polar House", to serve as a public contact point and to foster the development of a critical mass of polar expertise in Canada.

These three steps, taken together, could result in what might be called a Canadian polar institute. But they would not constitute a scientific institute in the commonly accepted sense of that word.
Furthermore, we wish to underline that we do not make these recommendations in the belief that they will immediately resolve all the difficulties facing polar research in Canada. We see them as a kind of "primer" that will give more focus and purpose to the polar research community and that will foster needed changes in the attitudes of government, the general public and northerners. The following paragraphs present some of our general thoughts on the nature of these bodies.

9.2 Features of the Proposed New Polar Research Bodies

9.2.1 Canadian Polar Research Commission

(1) The Commission should be appointed by and receive its mandate from a very senior level in the federal government in Canada, such as Cabinet or a central agency, so that it can be seen to in the service of all Departments and Ministries with northern or polar research interests;

(2) The Commission should be accountable to the Government and the public through a Minister, and should report publicly not less than once a year to that Minister or to Parliament.

(3) The Commission should be comprised of between six and twelve people, each of whom is experienced in and has shown a commitment to northern and polar research, scientific information and its use, and northern development in a broad sense. The members should be appointed for fixed terms and should serve as individuals, not in a representative capacity. Their collective expertise and interests should cover a wide range of polar disciplines and experiences. A substantial proportion should be full-time residents of northern Canada. Persons employed by the federal, territorial or provincial governments should make up less than half the members of the Commission;

(4) The mandate of the Commission should include :

(a) In co-operation with federal, territorial and provincial governments, universities, native organizations and industry, to review Canadian activities in relation to current and anticipated Canadian needs and objectives in the polar regions;

(b) to review the participation of Canadian science and Canadian research interests in international scientific activities pertinent to the polar regions;

(c) to review the participation of northerners and northern institutions in scientific activities in Canada, the responsiveness of scientific programmes to the needs and concerns of northerners, and the growth and development of an indigenous scientific research capacity in the North;

(d) to promote cooperation between Canadian scientists and scientific agencies and the scientists and institutions of other countries by: providing a Canadian point of contact; facilitating scientific liaison and exchange of information; and serving as host or co-ordinator of activities to promote, arrange and assess Canadian participation in international scientific programmes in polar regions;

(e) to provide a focal point for the development of the scientific aspects of Canada's interests in Antarctica, and to assess Canadian scientific activities in Antarctica;

(f) to oversee the development and operations of the Canadian Polar Information System;

(g) to oversee the development and operations, scope, effectiveness and problems of the Canadian "Polar House" and any affiliated facilities;

(h) to promote the transfer of accurate and up-to-date knowledge about the Canadian North and the polar regions into Canadian educational systems, particularly in the North;

(i) to consider the roles, interests, and effectiveness of public interest and citizens' groups concerned about northern science, environment or resources;

(j) to submit recommendations and advice to the federal government on any or all of (a) to (i) above.

(v) The annual report of the Commission should include a review of polar science in Canada, its relevance to national objectives and policies, and the adequacy of research funding. It should identify areas of research priority, areas that are neglected and need more attention or resources, areas of less relevance or poor scientific return where efforts should be reduced or diverted elsewhere, areas where international co-operation should be strengthened, and actions needed to foster the growth of indigenous scientific research in northern Canada. These questions should be addressed in a manner that will lead to a response or explanation from appropriate levels in the federal government. Subsequent reports by the Commission should comment on the responses made and action taken;

(vi) the Canadian Polar Research Commission should not itself undertake or sponsor research. However, it should have sufficient funds to undertake review activities, organize workshops or conferences, participate in international polar affairs and to meet other expenses associated with carrying out its mandate;

(vii) In order to maintain objectivity and avoid conflict of interest, the Commission should be set up and administered independently from the federal Public Service. Members of the Commission should serve as volunteers, with travel expenses reimbursed and a modest, publicly known honorarium paid. Executive and administrative support should be engaged professionally. The administration of, and the accountability for, finances of the Commission should be combined with those for the Canadian Polar Information System and the Canadian "Polar House".

9.2.2 Canadian Polar Information System

It is important that the scope, mandate, and operations of the Canadian Polar Information System be developed in consultation with those managing the various arctic and science information systems already in place in Canada. In recent years, there have been a number of imaginative and successful efforts to achieve greater consolidation and compatibility among the various systems and data centres now in use. Prominent in these efforts have been the Arctic Institute of North America, the Canadian National Research Council and its Canada Institute for Scientific and Technical Information, the Northern Libraries Colloquy, the Offshore Technology Information Seminars, ACUNS, C-FER, and the Northern Offshore Information Resources reviews. In the United States, several government agencies have established major programmes to develop comprehensive systems for polar science information. The development of compatible information systems has been identified as a high priority by the national polar science bodies in Sweden and Denmark.

Internationally, the International Council of Scientific Unions, through its Committee on Data for Science and Technology (CODATA) and its subject-oriented World Data Centres (WDC's) is giving attention to the establishment of systems of data that are compatible between different regions and subjects; and the UNESCO Global Environmental Monitoring System, through its Global Resource Inventory Database (GRID) is investigating methods of linking highly technical information obtained from satellites to simple ground observations made by residents in sparsely populated areas. The Canadian Polar Information System should be compatible with world science data systems.

The development of personal computers and remote library terminals has made the full range of organized scientific information potentially available to students everywhere in the North, to small remote communities and field camps, and even to individual families. The Canadian Polar Information System should be designed to take advantage of these new technical developments.

The development of such a system would be a highly technical undertaking. It would be desirable to establish a technical advisory committee, with representatives from the principal existing Canadian agencies and systems. An ad-hoc planning committee should be appointed as soon as possible to set up the terms of reference for the technical advisory committee, and recommend the first appointments.

The Canadian Polar Information System should include a communication centre to serve as a clearing-house for information and inquiries about the Canadian North, and about the polar regions. The function of such a centre would be to tap the Canadian Polar Information System in response to specific inquiries or policy needs, and to interpret and disseminate that information in a form that is useful and comprehensible to those who request it.

9.2.3 Canadian "Polar House"

The Working Group was faced with a paradox in the responses of many people when they were asked what could be done to improve the state of Canadian science and research in the North and the polar regions. The most common complaint was the lack of information and contact among agencies concerned with polar research, and we heard often that what was needed was an institute to "co-ordinate" these disparate activities. On the other hand, the same people usually vigorously opposed the creation of a centralized authority that would manage, direct or co-ordinate the work of these numerous, independent research agencies. We believe that this paradox can in large part be addressed by creating a polar information and contact centre, where research bodies and interest groups work voluntarily in a single location, easing communication without losing their independence.

(a) There is much room for imagination and original thinking in regard to the concept of a "Polar House". There should be no shortage of suggestions. We believe, however, that the "Polar House" should be relatively modest, designed to meet the objectives summarized above, and flexible in its operations. It would be better to begin with a small institution with a modest core budget that can be sustained by the federal government for several years, than to start with an ambitious, entrepreneurial programme that would then depend upon cost recovery and several sources of funding but which would run the risk of collapsing from one year to the next.

(b) Some of the potential functions of **Polar House** include :

(i) to serve as headquarters for the Canadian Polar Science Commission, and housing its secretariat;

(ii) if technically feasible, to provide the home for the Canadian Polar Information System. It could possibly serve as the entry point for linkage with data systems in other countries;

(iii) to be the location of the polar science communications centre;

(iv) to serve as a rallying point and a host for other government and non-government organizations. Polar House should be designed as a centre of Canadian polar activities, with information and communications services, adequate public rooms and display areas, and office space made available at reasonable cost to governmental and independent non-governmental organizations and associations.

(v) to serve as a national centre for activities relating to the North and polar regions by organizing meetings, lectures and displays, making contacts for foreign visitors and providing a polar dimension to other similar public activities. In these ways, Polar House could focus on bringing northern and polar understanding to other parts of Canada and, by so doing, reinforce public awareness of its role as Canada's public centre for arctic science and information.

(c) After hearing many opinions, and indeed receiving some submissions directly on this subject, the Working Group has concluded that Polar House must be in the National Capital Region. Location in the National Capital would enable ready access to the federal agencies concerned with the North, the necessary information and communication systems, and the largest concentration of Canada's research community that is involved in pure and applied subjects in all parts of the polar regions. The National Capital is the focus for Canada's circumpolar and bi-polar activities.

(d) Possible tenants of Polar House are listed here only to show the kind of collective body that *might* be developed and which *might* benefit from, and contribute to, the development of a "critical mass" of polar expertise. We emphasize that none of these organizations has given consideration to this question or in any way committed themselves. None has given us permission to be named in this regard, and they are mentioned for illustrative purposes only:

- the Ottawa office of the Government of the Northwest Territories or new Territories to be formed from it;
- the Ottawa office of the Government of Yukon Territory;
- the secretariat of the Northern Scientific Training Programme;
- the Polar Continental Shelf Project.

- Association of Canadian Universities for Northern Studies;
- Canadian Arctic Resources Committee.
- The Ottawa offices of northern aboriginal organizations

(e) Although **Polar House** as a central physical entity should be located in the National Capital Region, the idea, if properly developed, is appropriate to many parts of Canada. The Working Group did not explore in any depth the possibilities and problems of having a number of such houses. However, we are sympathetic to the idea that there could be counterpart **Polar Houses** in several northern regions. The concept might also, in time, be developed by some of the university-based northern institutes.

(f) It is important that **Polar House** be independent of the regular operations of the federal government. The Working Group recommends that a small task force be set up, either by the Minister of DIAND or by the Canadian Polar Research Commission if it is appointed in the near future, to refine the concept of **Polar House,** design appropriate management, administrative and accountability structures, and consider what would be practical among the functions suggested above and others that may be proposed. The task force should report to the Canadian Polar Research Commission and include representatives from the Commission, the Canadian Polar Information System and federal and territorial agencies and other bodies who are potential tenants. The task force should be disbanded when its report has been submitted.

9.3 Financial Aspects

Many of the problems relating to scientific research and information in the polar regions are caused by inadequate financial resources. Almost every solution suggested to us would require the spending of more money. At the same time, the Working Group is aware of the current situation respecting the public financing of research in Canada; we have no reason to suppose that the situation will change significantly in the next few years.

A national polar research commission, with a mandate and responsibilities like those recommended in this report, should be funded mainly by the federal government. However, certain specific activities may be supported by matching fund arrangements with foundations and the private sector, or one-time endowment grants, or loan guarantees. The Commission should have built-in incentives to develop a means of mobilizing a broad range of funding sources.

A creative and entrepreneurial approach to diversifying the financing of the Commission, the Polar Information System, and "Polar House" should help ensure that these activities are well managed, and that they are in tune with the external environment in terms of the changing availability of financial resources, and in terms of the needs and priorities of Canada.

It is premature to attempt realistic estimates of the actual costs of implementing these recommendations. However, the costs would be very much less than the costs of establishing and maintaining a new, viable, independent, world-class polar research institute. Almost every field of research, scientific information and technology development in arctic Canada today is desperately short of money. This applies to government in-house scientific operations, federal, provincial and territorial, as well as to universities and private groups. Additional funds for polar research in Canada will be spent more effectively if channelled through existing government agencies and research institutes than by creating new ones.

It should be understood that the actions we are proposing, by themselves, will not improve the effectiveness of scientific activities in northern Canada if no additional funds are made available for northern and polar research. Funds for polar science, for the on-going scientific activities of government agencies, for university research funded through granting agencies and other science support bodies are needed. The Canadian Polar Research Commission, the Canadian Polar Information System, and Polar House are proposed in order to develop a sustained efficient Canadian commitment to polar research and to ensure Canada's investments in polar research are spent effectively.

10. RECOMMENDATIONS

On the basis of its review of the state of polar research in Canada, and after considering various actions that might be taken to improve and strengthen Canadian polar research and its usefulness to all Canadians, the Working Group respectfully submits the following recommendations.

1. **The Working Group recommends that a new, federally funded institution dedicated to undertaking, funding or managing research in the Canadian North and the polar regions NOT be established at this time or in the near future.**

2. **The Working Group recommends that a Canadian Polar Research Commission be established and appointed with a membership, mandate and duties based on the suggestions in Section 9 of this report. The Commission should submit annually to a designated Minister or to Parliament a report to be made public, containing an appraisal of the state of northern and polar science in Canada and suggestions for improvements.**

   It is suggested that a small representative ad hoc committee be appointed to develop the terms of reference and the mandate of the Commission.

3. **The Working Group recommends that a Canadian Polar Information System be established, building upon and linked to presently existing government, academic and industrial scientific data, information and bibliographic systems in Canada, and compatible with international polar-related information systems. The information system should be developed along the lines suggested in Sections 9.1 and 9.2.2 of this report.**

It is suggested that an ad hoc planning committee be appointed, comprised of persons familiar with both governmental and non-governmental northern information and science information systems in Canada and elsewhere. The committee should draw up terms of reference for a standing Technical Advisory Committee which would be charged with developing the details of the Canadian Polar Information System. This committee should report to the Canadian Polar Research Commission.

4. **The Working Group recommends that a publicly accessible centre of contact, communications and interests related to northern Canada, the Arctic, and the polar regions, tentatively called "Polar House" be established in the National Capital area. The House and its activities should be based on the general concepts suggested in Sections 9.1 and 9.2.3 of this report. A prime purpose of "Polar House" would be to give tangible visibility to Canada's commitment to polar science and the integration of scientific knowledge from polar and northern regions into all aspects of Canadian life, in the North and in southern Canada; it could also serve a number of very practical functions in an economical manner.**

It is suggested that a small task force be appointed to develop in greater detail the concept of "Polar House", including elements of its management and administration, physical facilities and costs. Possible duties and composition of the task force are suggested in Section 9.2.3(f) of this report. The task force should report to the Canadian Polar Science Commission.

5. **The Working Group recommends that the Federal Government adopt a policy of promoting the greater involvement of northern institutions and northerners, especially native northerners, in the determination of national priorities for polar research and the**

actual undertaking of northern research in Canada. Specifically, these policies should include increased financial and other support for northern institutions engaged in research activities in the North, effective participation by northerners in national institutions concerned with polar research, and measures to facilitate the access of northerners and northern institutions to the Canadian Polar Information System.

6. The Working Group recommends that a national polar science communications centre be established, as part of "Polar House" and drawing on the Canadian Polar Information System, to provide information about the Canadian North, the polar regions, and Canadian polar science to the Canadian public.

7. The Working Group recommends that, because of the increasing national and international importance of scientific knowledge of northern Canada and the polar regions, the federal departments engaged in scientific activities in the North give greater emphasis to their northern and polar research, and co-operate with the Canadian Polar Science Commission in determining scientific priorities and the most effective scientific activities in their areas of responsibility.

Respectfully submitted,

W.P. Adams
P.F. Burnet
M.R. Gordon
E.F. Roots (Chairman)

Office of the Science Advisor
Department of the Environment
OTTAWA, Ontario K1A 0H3

January 31, 1986

Dear Colleague, and Person Interested in Northern Science and Information:

Re: Consideration of a National Polar Institute for Canada

Last September, the Honourable David Crombie, Minister of Indian Affairs and Northern Development, announced his intention to consider whether a National Polar Institute should be established in Canada. He has asked me and three other individuals, each of whom has had considerable experience in northern institutional matters, research, communication and policy, -- Peter Adams, Peter Burnet and Mark R. Gordon -- to advise him on whether there is a need for such an institute, and, if so, how an effective institute should be constituted. I am writing to invite you and your organization to provide us with any views you may have on this question and to assist us by sharing with us your experience with research and information exchange regarding northern Canada and polar matters generally.

We will provide the Minister with our advice by the end of May. While it will not be possible for us to hold formal hearings, we do intend to seek out the views of as many experts and interests as possible over the coming months. In addition, we intend to visit Yellowknife and Whitehorse before the end of April to meet with northern governments, organizations or spokespersons from native groups, local industries and other interests to ensure that their perspectives are considered in our report.

On behalf of my colleagues, I invite you to provide us with your views by letter or by submitting a written statement to us. Should you wish to meet with us in Ottawa, Yellowknife, or Whitehorse, I would ask that you let me know at your earliest convenience so that I can make the necessary arrangements. As all four of us travel extensively in the course of our regular duties, it may be possible for one or more to meet with you in another city should you wish. While we cannot guarantee to meet or hear from everyone interested, we will do our best to accommodate any such requests.

In advising the Minister, we intend to address two major issues. The first is whether, in the light of the many institutions and activities presently interested in the Canadian north, there is a need for a national polar institute and, if there is, what is the nature of that need. In this regard, we are particularly interested in your views on what is lacking in northern research in Canada, what gaps or omissions exist in the scope or activities of present institutions involved in northern research, and how can those institutions and other interests be supported or assisted in their efforts to improve the quality of existing northern scholarship, science and technology, and communication. We will value your opinions about whether a national institute will help legitimate interests, in the north and in southern Canada, derive greater benefit from Canadian scientific activities, or whether such a body would merely add to the confusion.

Our second task will be to advise the Minister about future actions. This will involve recommending what kind of institution Canada should have if a new national institute is justified; where it is to be located, how it is to be controlled and funded, and what its mandate should be. If it is our conclusion that no new institution is required, we will consider making some recommendations about how the present mixture of polar-oriented scientific bodies and activities can be strengthened and made more effective. We are trying to look ahead at least a decade, so that our ideas and recommendations will not be tied to the economic circumstances and policy priorities of today; and yet what we recommend must be capable of being initiated in the immediate future, and reflect the realities of the resources, expertise and jurisdictions of Canada in 1986.

As a major Arctic nation, Canada should be a world leader in northern research and knowledge. We also need to be able to speak clearly and with expert knowledge on the international scene with regard to northern or polar research and scientific issues. The many existing universities, corporations, government agencies (federal, territorial and provincial), independent institutes, and northern aboriginal organizations that are involved in northern research, technology development and information exchange are proof that this nation has already an important body of knowledge respecting the North, and is actively adding to that knowledge. It is not our intention to criticize or supplant the efforts of any of these bodies or activities. Any changes that are made, if they are to be beneficial to polar science, Canadian scholarship, and northern social or economic development, must build on the results already achieved, and be helpful to the institutions and persons already committed to northern research and information. Our task is to consider how we can build upon these efforts by establishing, if it is needed and feasible, better institutional support and focus to ensure that Canada has the knowledge, and the capacity to maintain and improve on that knowledge, to look after its own northern and polar interests properly, and also to plan an appropriate international role in understanding and appreciating the many scientific, cultural, socioeconomic and technical issues related to the polar regions of the world.

We are most anxious that our report to the Minister be based on the views of the widest possible cross-section of interests, and would be very grateful for any assistance you can provide us on any or all of these questions. At the same time, we will not implicate you or your organization in any of our recommendations, and will hold strictly in confidence anything that you may wish to present to us in confidence. While each of us has professional duties and responsibilities, we wish to assure you that we are approaching this task as far as possible as concerned individuals, and that our respective organizations or employers do not have a vested interest in our participation in the exercise upon which we are embarked.

On behalf of my colleagues, I look forward to receiving your ideas on this important issue. You may send your comments to me at the above address, or to any of my colleagues at the addresses given below.

Yours sincerely,

E.F. Roots (signed)

cc: Dr. Peter Adams, Executive Director, Association of Canadian Universities for Northern Studies, #1915, 130 Albert St., Ottawa, Ontario K1P 5G4

Mr. Peter Burnet, Executive Director, Canadian Arctic Resources Committee, 46 Elgin Street, Room 11, Ottawa, Ontario K1P 5K6

Mr. Mark R. Gordon, President, Makivik Corporation, Kuujjuaq, Quebec J0M 1C0

APPENDIX B

EXAMPLES OF INTERNATIONAL POLAR INSTITUTES AND ORGANIZATIONS

Institute/Organization	Mandate	Main Sources of Support	Responsible Direction	Primary Activities
Alfred Wegener Institute (Germany)	Ministry of Science	Departmental budget	Government body	Polar research and field operations
Polar Institute (Japan)	Ministry of Science	Departmental budget	Government body	Polar research and field operations
Norwegian Polar Research Institute (Norway)	Norwegian Parliament Minister of Environment (1928)	Departmental budget	Minister & Director	Research, field stations and laboratory (Svalbard, Antarctic, marine); library; draft formal Norwegian polar positions; national centre for information on some natural sciences, representative for international polar activities
Committee for Polar Research (Sweden)	Agency of the Royal Swedish Academy of Sciences	The Royal Swedish Academy of Sciences and Swedish Council for Planning and Coordination of Research	Appointed Committee drawn from universities and research institutes	Initiation and support of Swedish polar research, focal point for information on polar regions; Swedish reference group for international cooperation in Arctic and Antarctic
The Scott Polar Research Institute (U.K.)	Charitable independent foundation, affiliated with The Royal Society	Royal Society, University, Research grants	Appointed Board of Directors, affiliated with Cambridge University	In-house research, library and archives. Information services and publications. Draft national positions and provide advice to government. Teaching.
Polar Research Board and U.S. National Committee on Antarctic Research (U.S.)	U.S. National Academy of Sciences (1958)	Congressional grant	Appointed independent members, and Academy policies	Advisory board on U.S. programs in the polar regions. Organizes panels to investigate science subjects. Comment publicly or in confidence on national/international developments. Representative for international polar activities.
Arctic Research Commission (U.S.)	Act of Congress (1984)	Congressional grant	Appointed Members	Develop & recommend integrated Arctic research policy; assist in developing a national Arctic research program plan; facilitate cooperation between federal, state and local governments with Arctic research; review Federal research programs; recommend methods to improve logistical planning; suggest methods for improving efficient sharing and dissemination of data and information.
Arctic and Antarctic Research Institute (USSR)	Government, Ministry of Hydrometeorology	Departmental budget	Government body; Director	Natural sciences; polar operations; field stations; library; publications.

APPENDIX C

Notes on Some Major Previous Reviews Regarding The Organization and Conduct of Northern and Polar Science

In 1955, The Arctic Institute of North America, with scientific representation from Canada, Greenland and the U.S. undertook a comprehensive study of the status of arctic research in the various fields of science. The report of the study was published in a volume entitled Arctic Research which included a description of trends in the physical, biological and social sciences and the identification of future research needs.

In 1963, The Arctic Institute of North America released a report entitled The Arctic Basin, which presented an evaluation of the status of scientific and operational knowledge, and identified pressing research problems in the environmental and social sciences. Recommendations were made concerning the need for continuity of research programs with a view to achieving an increased ability to predict conditions in the Arctic, increased knowledge of design criteria and of the feasibility of mobile and static operations, and an increased capability to understand the importance for the North of environmental conditions external to the Arctic. The need for institutional core funding by government, in addition to "project" funding for specific studies which could be supported by government agencies or industries as appropriate, was stressed.

In 1964, The Royal Commission on Government Organization reviewed the organization and conduct of northern scientific research and development. The Commission made recommendations concerning the coordination of scientific work and the determination of priorities within the Federal Government, and the establishment of centrally administered northern research facilities within DIAND.

In 1966, The Arctic Institute of North America submitted to the Canadian government a proposal for A Centennial Fund for Northern Research in Canada, which included a "centennial review" of the status of research in the Canadian North. It made recommendations concerning the requirement of long-term funding and future research needs in the physical, biological and human sciences.

In 1970, the Committee on Polar Research of the U.S. National Academy of Sciences issued a report, Polar Research - A Survey. Its primary purpose was to review the status of knowledge, needs, and opportunities for future research in the Arctic and Antarctic. The report drew on the experience and special knowledge of polar scientists primarily in the U.S. but also with important Canadian representatiaon. Major scientific problems in each major field were identified. Recommendations were made for the physical and natural sciences and medicine, and with regard to international cooperation and logistics.

The 1972 seminar on Guidelines for Scientific Activities in Northern Canada was sponsored by the Advisory Committee on Northern Development "to assist in developing guidelines and priorities for scientific activities in support of the objectives and priorities for northern Canada, as stated by the government". Working groups of scientists and specialists from the academic community, industry and government reached a consensus on science needs, and produced summary statements, regarding guidelines and priorities concerned with: northern people, natural environment, renewable resources, technology, and international research. Three areas where there appeared to be a general consensus were: (1) to increase the involvement of native people in research, and in the use of science and technology in the North; (2) to create jobs for native people in the North - jobs that are perceived by the native people to be important and interesting, e.g. jobs in relationship to renewable resources and in the recreational use of renewable resources; and (3) devising a better system for ready access to information on the Arctic, one based on access to first class library material, with international connections, and with a staff who are experts in the major fields.

Through 1976 and 1977 the Science Council of Canada produced a series of studies on the North which focussed on: the decision-making process for northern development; policy concerns; the pacing of northern development and the relationship between the technological, economic, sociological and political aspects of northern development. The final report Northward Looking, A Strategy and A Science Policy for Northern Development included recommendations covering the principles of a science policy for northern development and for scientific, technological, information, education and institutional initiatives that would support a strategy of balanced development in the North.

In 1977, the Ministry of State for Science and Technology issued A Commentary on the Inventory of Federal Northern Science Projects, 1975-1976. The report recommended: development of a general policy and program framework for the planning, funding, and assessment of the northern scientific and technical effort; that attention should be given to having the scientific activities conform more closely to some aspects of "the (1976) Guidelines for Scientific Activities in Northern Canada"; reconsideration of the adequacy of funding for northern science given the importance of the North to the rest of Canada; the special significance of science in this region; and increased research on northern medical problems.

In 1979, the Marine Board and the Assembly of Engineering of the U.S. National Research Council undertook a review of critical needs in polar ocean engineering. The report, Engineering at the Ends of the Earth, published by the U.S. National Academy of Sciences, reviews polar ocean engineering research and technology necessary to support commercial and scientific operations in the decades ahead, examines technical deficiencies in the state of the art and recommends ways of improving polar engineering related to resource development, transportation, communications, and data.

In 1982, the Polar Research Board of the U.S. National Research Council issued a document on A United States Commitment to Arctic Research which reviewed the state of northern research, its organization and support and recommended that: (1) "U.S. Government science policy should include a commitment to the support of scientific research in its Arctic territory and in other areas of Arctic interest....", (2) "To assure productive polar research, the U.S. Government should improve the coordination and effectiveness of Arctic research programs, and provide stability and continuity of effort". This document, together with a report on the same theme prepared by the Alaska Division of the American

Association for the Advancement of Science, was influential in setting in motion activities that led to the passage of the U.S. Arctic Research and Policy Act.

In 1984, the Committee for Polar Research of The Royal Swedish Academy of Sciences issued Swedish Polar Research which provided a comprehensive document of Swedish polar research projects, scientists and physical facilities and a commentary on the need for continued scientific activities in the polar regions.

In 1985 a working group appointed by the Danish Minister for Greenland issued a consultative Report on the Establishment of a Multidisciplinary Polar Institute in Denmark. Proposals were made for the establishment of an institute which would function as an advisory and research body, and which would house a library and information centre, and a museum.

The Nordic Council (representatives from Denmark, Finland, Iceland, Norway and Sweden) has held a number of international meetings or conferences on arctic research since 1984. Representatives from Canada have been invited to several of these, which have undertaken reviews or analyses of the state of arctic research and its support, the incorporation of arctic science into education or into industrial practices, and international co-operation. The Rapports from these conferences contain recommendations for government action.

Early in 1986, the U.S. Arctic Research Commission issued a report National Needs and Arctic Research: A Framework for Action as a basis for developing a comprehensive five-year Arctic research plan. In order of priority the Commission made recommendations on: research to understand how the Arctic Ocean and the Arctic atmosphere operate as a coupled system; research to understand the coupled atmosphere-land system; research to understand the high-latitude upper atmosphere; research on the health-culture-socioeconomic system to identify and resolve major northern health, behavioural and cultural problems; consolidation of Arctic data and information transfer systems; furthering research platform and logistic systems, and international cooperation in Arctic research.

As part of the preparation for a U.S. five-year Arctic research plan, the U.S. Interagency Arctic Research Policy Committee, representing eleven U.S. federal government agencies involved in arctic research, produced two documents:- Federal Arctic Research: Detailed Listing of existing U.S. Programs (1985), and Federal Arctic Research: Draft Recommendations for Necessary Programs (1986). These reports, together with the report of the U.S. Arctic Research Commission noted above, have been the bases for a series of public meetings and workshops during 1986 which have led to a report, due in July 1987, on a U.S. Federal 5-year Arctic Research Plan.

Mid-way through 1986, the Inuit Circumpolar Conference issued Draft Principles For An Arctic Policy covering: Inuit rights; peace and security; and environmental, social, cultural, economic, educational and scientific issues.

In 1986, an international workshop was organized by the International Institute for Environment and Development to consider changing needs and directions in Antarctic science and politics, and their implications for future research and the use of research results. The report, Future Directions for the Management of Antarctic Science examines problems of international co-ordination, priority setting, co-operation in logistics and operations, and the management of international research in polar regions.

In 1986, the Committee on Arctic Geosciences of the U.S. Polar Research Board issued a report Antarctic Solid-Earth Sciences Research: A Guide for the Next Decade and Beyond which advocates a change in the direction of U.S. geosciences research in Antarctica to give more focus to emerging major scientific problems, and an example of the long-range planning now seen to be necessary for effective polar research.

A number of other organizations have conducted reviews of particular aspects of northern science. The Association of Canadian Universities for Northern Studies, for example, has organized conferences and published proceedings on such overview topics as Renewable Resources and the Economy of the North (1981), Arctic Heritage (1987) and Education, Research, Information Systems and the North (1987) for science in the North. Similarly, the Canadian Arctic Resources Committee has produced symposia-based publications, such as Arctic Alternatives (1972) and Marine Transportation and High Arctic Development: Policy Framework and Priorities (1979), as well as position papers in its newsletter, Northern Perspectives. The Arctic Petroleum Operators' Association has produced similar reviews.

9-10 GEORGE VI.

CHAP. 45.

An Act to incorporate The Arctic Institute of North America.

[*Assented to 18th December, 1945.*]

WHEREAS Dr. Charles Camsell, Deputy Minister of Mines and Resources; Walter Stowell Rogers, Director, Institute of Current World Affairs; George Raleigh Parkin, businessman; and Dr. John Johnston O'Neill of the Department of Geological Sciences, McGill University, have by their petition on behalf of the unincorporated association known as the "Arctic Institute of North America" prayed that it be enacted as hereinafter set forth and it is expedient to grant the prayer of the said petition: Therefore His Majesty, by and with the advice and consent of the Senate and the House of Commons of Canada, enacts as follows:

1. The said Charles Camsell, Walter Stowell Rogers, George Raleigh Parkin and John Johnston O'Neill, and all other members of the association mentioned in the preamble, hereinafter called "the unincorporated Institute", together with such persons as may hereafter from time to time become members of the corporation hereby incorporated, are incorporated under the name of "The Arctic Institute of North America", hereinafter called "the Institute". **Incorporation.** **Corporate name.**

2. The objects of the Institute shall be, in general, **Objects**

(a) to initiate, encourage, support and advance by financial grants or otherwise the objective study of arctic conditions and problems, including such as pertain to the natural sciences, sciences generally and communication;

(b) to collect, arrange and preserve records and material relating to the arctic regions, and especially to such areas thereof as form part of or are contiguous to the Continent of North America;

(c) to make such records and material available for pure and applied scientific use by properly qualified individuals and organizations, including governmental agencies;

(d) to arrange for or to assist in the publication of reports, maps, charts and other documentary material relating to the arctic regions;

(e) to establish and maintain close contact with other Arctic Institutes and organizations engaged in similar or related fields of study.

Power to constitute local branches and executives.

3. Subject to the by-laws of the Institute local executives or branches may be constituted under such title and designation, subject to such conditions and provisions, and with such powers as the Institute may determine by by-law: Provided, however, that such powers shall not be in excess of those conferred on the Institute by this Act.

Powers by rules and by-laws.

4. The Institute may by rules or by-laws which it may make—

Members and fees.

(a) define and regulate the admission, suspension and expulsion of members; determine the different classes of members and their rights and privileges; and fix the fees, if any, subscriptions and dues to be paid by them;

Board.

(b) establish a Board of Governors of the Institute with executive power; determine the method of election or appointment thereto or selection thereof; define the constitution, powers, duties, quorum and term of office of such Board, and fix the number, powers, duties and term of office of the officers and committees of the Institute and of the local executives and branches;

Annual and other meetings.

(c) fix the time and place for holding the annual and other meetings of the Institute, and the notice to be given thereof:

Administration and management.

Delegation.

(d) provide for the administration and management of the business and affairs of the Institute and the furtherance of its objects and purposes, and such delegation as it may deem proper of any of its powers to the Board of Governors of the Institute.

Powers.

5. (1) The Institute may for the purpose of carrying out its objects—

Property.

(a) subject to provincial laws, acquire by purchase, lease, gift, legacy or otherwise, and own and hold any real estate and personal estate and property of all kinds, rights or privileges, and sell, manage, develop, lease, mortgage, dispose of or otherwise deal therewith in such manner as the Institute may determine:

Provided that real estate held by the Institute shall not exceed in value at any one time the sum of five hundred thousand dollars, and no parcel of land or interest therein, at any time acquired by the Institute and not required for its actual use and occupation and not held by way of security, shall be held by the Institute or by any trustee on its behalf for a longer period than ten years after the acquisition thereof, or after it shall have ceased to be required for actual use or occupation by the Institute, but at or before the expiration of such period be sold or disposed of, so that the Institute shall no longer retain any interest or authority therein except by way of security;

Bills of exchange

(b) make, accept, draw, endorse and execute bills of exchange, promissory notes and other negotiable instruments;

Investment.

(c) invest the surplus funds of the Institute in such manner and upon such securities as may be determined;

Borrow

(d) borrow money as and when required for the purposes of the Institute;

General

(e) do all such other lawful acts and things as are incidental or may be conducive to the attainment of the objects of the Institute.

Not to issue bearer notes etc.

Business of banking or insurance prohibited

(2) Nothing in this section shall be deemed to authorize the Institute to issue any note payable to the bearer thereof, or any promissory note intended to be circulated as money, or as the note of a bank, or to engage in the business of banking or insurance.

Present officers' tenure.

6. The present officers and members of the Board of Governors and of the Committees of the unincorporated Institute shall, subject to the by-laws or rules of the unincorporated Institute, continue to hold their offices until their successors shall have been appointed or elected in accordance with the provisions of this Act and of the by-laws and rules made thereunder.

Existing constitution, by-laws and rules retained.

7. The existing constitution, by-laws and rules of the unincorporated Institute, in so far as they are not contrary to law or to the provisions of this Act, shall be the constitution, by-laws and rules of the Institute until altered or repealed at an annual or special general meeting of the Institute.

OTTAWA: Printed by Edmond Cloutier, Law Printer to the
King's Most Excellent Majesty.

REFERENCES

Antarctic Treaty System: An Assessment, Proceedings of a Workshop held at Beardmore South Field Camp, Antarctica, Polar Research Board, National Research Council, National Academy Press, Washington, D.C., 1986.

Arctic Ocean Engineering for the 21st Century, Ben C. Gerwick, Ed., Marine Technology Society, Washington, D.C. 1985.

Arctic Research, The Arctic Institute of North America, Ottawa, 1955.

Canada's Northern Stations, G.T.J. Campbell, P. Adams, Association of Canadian Universities for Northern Studies, Ottawa, Ont., 1986.

Draft Principles for an Arctic Policy, Inuit Circumpolar Conference, ICC General Assembly, Kotzebue, Alaska, 1986.

Interdependence and Internationalism, Report of the Special Joint Committee of the Senate and of the House of Commons on Canada's International Relations, Government of Canada, Ottawa, 1986.

National Issues and Research Priorities in the Arctic, Polar Research Board, U.S. National Academy of Sciences, Washington, D.C., 1985.

National Needs and Arctic Research, A Framework for Action, U.S. Arctic Research Commission, 1986.

Northward Looking, A strategy and a Science Policy for Northern Development, Science Council of Canada, Report No. 26, 1977.

Report on the Establishment of a Multidisciplinary Polar Institute in Denmark, The Commission for Scientific Research in Greenland, 1985.

Polar Research, A Survey, Committee on Polar Research, National Academy of Sciences, Washington, D.C., 1970.

Science and the North, A Seminar on Guidelines for Scientific Activities in Northern Canada, Mont Gabriel, Quebec, Advisory Committee on Northern Development, Government of Canada, 1972.

Sixth Annual Conference, Regina, Saskatchewan, Report 1983, Association of Canadian Universities for Northern Studies, Ottawa, Ont. 1983.

The Arctic Basin, J.E. Sater, The Arctic Institute of North America, Washington, D.C., 1969.

The Arctic Ocean: The Hydrographic Environment and the Fate of Pollutants, L. Rey, Ed., Comité Arctique International, MacMillan Books London, 1982.

THE AUTHORS

W.P. Adams is Professor of Geography at Trent University, Peterborough, Ontario and Executive Director of the Association of Canadian Universities for Northern Studies of Ottawa.

P.F. Burnet is a lawyer and former Executive Director of the Canadian Arctic Resources Committee of Ottawa.

M.R. Gordon is President of Makivik Corporation of Kuujuaq, Quebec and a member of the Board of Directors of Inuit Tapirisat of Canada.

E.F. Roots is Science Advisor to the Minister of the Environment, Ottawa and former Co-ordinator of the Polar Continental Shelf Project.